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THE MONTH.

AMONG the various causes which militate against the popularity of mechanically propelled vehicles, the unsuitable construction of road surfaces is not the least. No doubt pleasure cars are responsible, more than any other type of motor vehicle, for stirring up the clouds of dust that hang over our highways in dry weather, but the same effect is produced to some extent by light motor vans and omnibuses. Hence all who are interested in the extended use of such vehicles should support the movement for the reform of highway construction. Many experimental stretches of road have been laid in Surrey and elsewhere with tar macadam, and after enduring the wear of summer and winter these sections remain in excellent condition. In some places where existing surfaces were simply treated with tar, renewal of the coating has been necessary, but in others where specially made tar macadam was employed the road surfaces are practically uninjured. Dust-laying liquids do not go to the root of the matter, however useful they may be as palliatives. What we want is a radical reform in the practice of modern road construction.

A return recently published by the French Government brings out in a very striking manner the progress made during the six years 1899 to 1904. The statistics are classified so that the growth of commercial and private vehicles may be separately studied. In the former class the number of cars has increased from 234 in 1899, to 4,588 in 1904, and in the latter class the increase has been from 1.438 cars in 1899 to 12,519 cars in 1904. Turning to the table of exports and imports we find an amazing growth in the excess of exports over imports, the difference in 1904 reaching the total value of about £2,700,000. Of this amount it is probable that more than half represent exports to Great Britain. Taking into account the imports from other countries, it is clear that a moderate duty on foreign-built cars should provide either a most acceptable addition to the revenue or a still more welcome increase of employment for British workmen.

One of the most satisfactory developments in connection with the motor industry is the readiness exhibited by railway companies to establish services of motor omnibuses. Naturally, the main object is to afford facilities for the transport of passengers and luggage between their homes and the railway stations or between railway stations and hotels. There is reason to believe, however, that the general public may desire to make some use of the services so provided, and we see no objection whatever to the practice. This is not the view of municipal authorities who have foolishly rushed into tramway enterprises. Finding the remunerative character of such undertakings to be a very doubtful asset, these licensed spendthrifts now seek to suppress railway competition. The latest movement in this direction is to be found in the decision of

the Municipal Tramways Conference to oppose the Bill of the North Eastern Railway for empowering the company to run motor omnibuses. The proposal is that in districts provided with municipal tramways the use of railway road vehicles shall be limited to actual railway passengers, unless the written consent of the local authorities be obtained to a more extended service. The audacity of this proposition is amazing. We wonder what municipal authorities would have said to the suggestion that no tramways should be started in districts already served by railways or omnibuses without the written consent of the companies or proprietors. The ratepayers of Great Britain would now have occasion for rejoicing if such a law had been in force during the last ten years.

At a time when the consideration of alcohol as fuel is before many of our readers, it may be interesting to place on record the methods of denaturation adopted in the chief European states. In France, alcohol is treated by the addition of 10 per cent. of methylene containing 0·5 per cent. of heavy benzine of dark colour and unpleasant odour—a method which diminishes calorific value and increases the fouling of cylinders and valves. Italian motor alcohol, containing about 1 per cent. of benzol, is treated with 8·5 per cent. of impure methylene and 0·66 per cent. of pyridine, and for the sake of distinction the spirit is coloured violet by aniline dye. Swiss alcohol contains 5 per cent. of methylene, 0·33 per cent. of pyridine, and 2·2 per cent. of oil of acetone, which gives a very disagreeable odour and an opalescent yellow colouring. Wiser counsels in Austria and Germany have prevailed for several years, special methods of denaturation being applied to spirit for power purposes. In the former country alcohol, containing at least 2·5 per cent. of benzol or mineral hydrocarbon, is denatured with only 0·5 per cent. of methylene and a trace of pyridine, and is coloured violet. In the latter country motor alcohol, containing a minimum of 2 per cent. of benzol, is denatured with 1 per cent. of methylene and a small quantity of pyridine. It is coloured violet but not so deeply as in Austrian practice. The proposal made by the Departmental Committee on industrial alcohol is that ordinary methylated spirit should contain only 5 per cent. of methylic alcohol instead of 10 per cent. This is a move in the right direction, but we hope that no obstacles will be placed in the way of those desiring to employ special agents for the purpose of denaturation.

As the pleasure car prepared the way for motor vans, so the pleasure boat is now engaged in helping forward the application of motor power to industrial navigation. We must take care, however, that the sporting instinct does not divert attention too long from the commercial aspect of things. That this warning is by no means unnecessary is a fact that may be gleaned from the report prepared for the Secretary for Scotland by Lieut. Cumming, R.N. This document shows that motor power has been successfully applied on an extensive scale to fishing boats in various German and Scandinavian ports, and should have the effect of bringing home to our own engine builders the desirability of catering for the requirements of the fishing industry. One Danish maker has fitted his motor into nearly five hundred boats and is carrying on an important export trade. He now offers liberal terms to purchasers in this country, and is prepared to fit them into any boats on the free trial system. This shows very complete confidence in his engine and proves the necessity for immediate action on the part of British makers.

We are glad to observe that various suggestions made by the Motor Van and Wagon Users' Association have been adopted by the Automobile Club in connection with the van trials which are to take place in September next. These trials are to be limited to loads of two tons and under, and there can be no doubt that they will be of much value in stimulating the improvement of a most useful type of vehicle. Nevertheless, it is somewhat to be regretted that the club thought fit to exclude heavier vehicles, especially considering the policy of reserve which prevails among railways and carrying companies in the metropolis with regard to the adoption of mechanically-propelled wagons. Although some tentative use has already been made of motor vans by the companies in question, their general attitude continues to be one of uncertainty and doubt. It is a satisfactory sign that the Motor Van and Wagon Users' Association are anxious for a competition of vans capable of taking heavy loads, and we hope the Automobile Club will recognise the desirability of dealing with this matter at an early date.

An experiment conducted at the laboratory of the Automobile Club of France throws

useful light on the influence of exhaust silencers upon the power developed by motors. The test in question was made with a 4-cylinder Peugeot motor having a water-cooled silencer, and when the apparatus was adjusted so as to reduce sound to the greatest possible extent the loss of power was 5 per cent. But the silencer was fixed upon a stand and connected with the exhaust outlet of the engine by a tube having three bends, a length of 6 ft., and an internal diameter of $1\frac{11}{16}$ in., the diameter of the exhaust outlet being $1\frac{13}{16}$ in. As the apparatus had previously been attached directly to the outlet, the experimenter thought it would be desirable to ascertain the loss of power due to the passage of gas through the tube so that the value might be deducted from the results obtained. It was then found that when the exhaust gases were allowed to escape freely into the air, the power developed by the motor was less than when the gases were passed through the tube. Numerous trials and careful examination of the measuring instruments proved that this effect actually took place, the recuperation caused by the tube being 1·4 per cent. This unexpected result is thus explained by Mr. Arnoux, the vice-president of the technical commission, by whom the experiments were conducted: "The gases, on leaving the motor, possess an actual power which must be absorbed by a system of laminæ, by friction, or by cooling, which by causing contraction of the gases effects a diminution of their velocity. The tube used experimentally was in reality nothing but an apparatus presenting a large cooling surface." From the experiments to which reference is here made, we see how desirable it is that the question of exhaust pipes should be carefully studied, and how important is the influence of a large cooling surface upon the efficiency of exhaust silencers.

At the dinner of the Society of Motor Manufacturers and Traders, Dr. Ormandy, in opening a discussion on the possibilities of alcohol as a fuel for automobiles, pointed out that petrol being a foreign product, its supply might be cut off in time of war. This is a somewhat remote contingency, but it must not be entirely overlooked. A more pressing point is that the supply of petrol is very uncertain in amount, thereby involving serious fluctuations of price. At the present moment the cost of this fuel is 6*d.* a gallon, but it will probably rise before long, and may reach the price of 1*s.* a gallon, as it has done before. This would mean a very heavy burden on the owners of motor vehicles, and could not fail to discourage purchasers of new machines. The present position is unsatisfactory in the extreme and distinctly at variance with the principles of sound economy. Fortunately we have an alternative fuel in alcohol that can be produced within the boundaries of the kingdom. The only disability attending its manufacture at a reasonable cost is to be found in the revenue restrictions, which must be entirely swept away. Then we shall see large areas of land in England and Ireland applied to the growing of potatoes for the production of spirit, restoring prosperity to agriculturists and benefiting two great British industries. Further, when we have free trade for home-produced industrial alcohol, the building of alcohol motors for the colonies and hot countries will become an important branch of manufacture. The whole subject is one that should be pressed on the attention of Parliament with the object of securing a sweeping readjustment of the existing fiscal policy, so far as concerns the production and use of alcohol for power purposes.

It is difficult to imagine why any opposition should be aroused to so reasonable a proposal as that embodied in the Vehicles' Lights Bill, which was lost by the narrow majority of one vote, at the end of May. The object of the Bill, as of its predecessors, was to make compulsory the carrying of red tail-lights by horse-drawn vehicles throughout Great Britain. As matters stand this regulation is enforced in various well-managed counties, and the County Councils Association have already petitioned the Local Government Board to use their influence in favour of universal lighting. However, a good many foolish people, including more than a hundred members of Parliament, still think it necessary that motor vehicles, which are not readily overtaken, should bear tail-lights, and that slow-going wagons should remain unlighted. In view of the danger presented to all users of country roads at night by crawling wagons, we are extremely sorry to find that so many members of the House of Commons are still in the somnolent condition, generally characterising the drivers of the vehicles which constitute so serious a peril to the public at large.

At a time when the feverish desire of municipal authorities for tramway enterprise has by no means subsided, we may usefully draw attention to the wise policy

of the Eastbourne Corporation in establishing a complete service of motor omnibuses. By means of this service all the benefits of a tramway system have been obtained without disfigurement of the streets or interference with other traffic. The financial success of this venture is a feature which renders it particularly interesting to ratepayers throughout the whole country, and the example of Eastbourne is one that deserves imitation.

Bearing in mind the very different character of the exhaust gases from an internal-combustion motor and the exhaust steam from a steam engine, it is evident that the compounding of petrol motors must proceed on original lines if success is to be attained. In the Pollard compound petrol engine the principle followed differs considerably from any previously adopted, and, so far as can be judged from tests conducted with an experimental engine, it seems probable satisfactory results will be obtained. Some difficulties in the way of compounding have already been overcome by this invention, the progress of which will be followed with interest. Among the advantages it evidences over previous attempts are that a smaller proportion of the additional power due to compounding is lost in overcoming the friction of the low-pressure piston, that the exhaust gases commence their work after a shorter interval of time, and that the high-pressure piston and exhaust valve shows no tendency to become overheated.

A direction in which motor road wagons may be employed with much advantage to farmers and market gardeners is by the establishment of regular collecting and distributing services in conjunction with district depôts, similar to those provided by the great carrying firms in the metropolis. Under the existing regime the cost of carting produce to the nearest railway station is not only too costly, but it also involves the despatch of unnecessarily small consignments from the various stations, thereby militating against the reduction of heavy railway rates. Moreover, the cartage of agricultural machinery and supplies to farmers and others is at present far more costly than it need be. Several railway companies have shown commendable activity in the way of starting motor services for the collection and delivery—if we may use the term—of passengers, and there is every reason why they should bestir themselves in a similar manner with regard to goods traffic. We do not for a momen class ourselves with those who believe that in some parts of the country, light railways and motor-cars will supersede regular railway services. But these more modern means of conveyance will do the railway companies considerable injury, unless the responsible managers show themselves ready to appreciate, and quick to adopt, the auxiliary means now available for feeding their main and branch lines with traffic from the districts traversed. The duty of every railway is to consult the interests of prospective customers in every possible way, and the performance of this duty will bring its own reward.

As a practical example of the way in which the interests of agriculturists and railway companies may be served by the aid of motor services, we may refer to the co-operative action of the North-Eastern Railway Company and the Brandsby Dairy and Trading Association. This organisation has established a depôt in the village of Brandsby, where farm produce is collected together for transport in bulk, and from which goods are distributed to the surrounding farms. With the object of securing the traffic, and, at the same time, of helping the farmers, the North-Eastern Railway have started a regular road motor service between Tollerton Station and Brandsby. Although the service has only been in operation for a few months, the results are distinctly encouraging. The farmers are able, on one hand, to make better conditions with the wholesale dealers, and on the other they save 2*s.* per ton on the cartage of goods consigned to them. The benefit accruing to the railway company by dealing with an association are a marked reduction in the cost of collection, delivery and transport, and increase of traffic.

The Traffic Problem in Large Cities.

By PHILIP DAWSON, M.Inst.C.E., M.I.E.E.

THE traffic problem never assumes precisely the same aspect in any two individual cases, and in dealing with any one large city it is necessary to pay special attention to the conditions which there obtain. At the same time the main features of the problem are more or less common to all large centres of population, and an investigation in the case of one particular British city, if conducted on broad lines, will furnish results which will be found to apply very closely to the numerous other large cities in this kingdom. Undoubtedly the case which is attracting the greatest interest at the present time is that of London, and it is therefore proposed to deal almost exclusively with the question of rapid transit in the capital without touching more than very lightly upon the requirements of the other big industrial and commercial centres. London, in some respects, certainly holds a unique position with respect to the traffic problem, but at the same time the study of the conditions obtaining in that immense city will be exceedingly helpful in bringing out the knotty problems connected with the introduction of further rapid transit facilities in other large cities.

The traffic in London is, or is about to be, provided for by several means. It is handled electrically by surface tramways, by shallow subways, such as the Metropolitan and Metropolitan District Railways, shortly to be electrified, and the shallow conduit tramway constructed by the London County Council, and by deep tube lines, including the pioneer "tube" of the world, the City and South London Railway. The work of the electrical tramways is aided by horse 'buses, which are at present in many cases being withdrawn in favour of petrol 'buses, and there still exist some ancient horse tramcar systems which have still to be superseded. Last of all, but by no means least, we have to reckon with the numerous steam railways radiating from the heart of London into the surrounding suburbs. This last means of transit is, as will be shown later, one of the most important of all those that have been mentioned.

The traffic conditions in England, and perhaps more particularly in London, are very different from those found in cities abroad. This is almost entirely owing to the prevailing desire amongst Englishmen to possess houses of their own. It is true that at the present day the "flat" system has enormously increased, but in the majority of cases there has come about, through the pressure of circumstances rather than by the free will and wish of the people as a whole, and even so, flats as a rule are intended rather for the rich than for the poor. The typical Englishman undoubtedly prefers to have a house of his own if he can possibly manage it, and as a consequence there are around London a large number of small houses spread over a wide area. The available space in the immediate outskirts of London has thus speedily become filled up with these small independent habitations, and later-comers must perforce live in flats or go further afield in search for a home. Hence there is the most urgent need for cheap and commodious and rapid means of transport whereby all these people may travel to and from their work in the City every morning and evening. It is indeed this bringing of the people in from the suburbs and taking them back in the evening which constitutes the chief problem to be faced by every populous city in the British Isles.

FIG. 1.—CAR AND OVERHEAD CONSTRUCTION, CORNER OF UNION STREET AND ARGYLE STREET, GLASGOW.

It behoves us, then, to consider most carefully what part is played by each of the various means of transport available in giving the inhabitants the facilities which they so urgently require.

In the first place, it should be clearly recognised that the sphere of useful action of electric tramways is necessarily closely limited by the restricted speed and the numerous stops. In most cases the average speed is inferior to ten miles an hour, and though in special cases it might be possible to run at a schedule speed of twelve miles an hour, such a speed cannot safely be reckoned on. Hence this means of transport cannot be relied upon for anything beyond short distance traffic, say, of from three to five miles. For this purpose it is absolutely unequalled, and consequently in a perfectly organised system of traffic the electric tramway would act almost solely as a distributor of the mass of travellers "dumped" at terminal stations by other and faster means.

It may be of interest to give a few illustrations of some of the largest tramways in existence in England and other countries at the present day. Fig. 1 shows the type of car used at Glasgow, Fig. 2 gives a view of the Washington N. T. conduit line, and Fig. 3 shows the London County Council conduit line.

Tubes and shallow conduits are likewise essentially distributors of passengers brought from afar by other means, though in a lesser degree than tramways, on account of the higher speed which can be maintained, which enables them to act as "through carriers" for longer distances than is possible with tramways.

It is indisputable that at present there is a considerable amount of through traffic carried by the tramways and tubes of London, but this condition of affairs cannot be regarded as normal; it has grown up because there has been no better way for the people to travel. The steam railways are the true means of through communication between the outlying districts and the heart of the City, and it is only because they have not kept up with the requirements of the times that they have been in many cases superseded by the more modern lines which have been constructed.

A careful study of the railway map of London and the surrounding district

should be sufficient to convince the greatest sceptic as to the suitability of the existing railway lines for the purpose of conveying the suburban residents to and from their work in the City. The only reason why the steam trains have failed in this work is because, though the service they have given has failed in the two great qualities necessary—*i.e.*, it has been neither fast nor frequent. It is true that there are certain fast trains running in from certain places in the morning and out again in the evening, but such trains are few and far between, and even the speed is attained by omitting to stop at most, if not all, intervening systems.

The steam railways are unable to provide proper facilities for the great travelling public, firstly, because the stations on the routes served are so close together that stopping trains never have a chance to make any speed, and secondly, because the present congestion in the termini is so great that any increase in the number, and consequently frequency, of the trains cannot be entertained under existing conditions.

It should be pointed out here that apart from the present shortcomings of the service given, the steam railways offer a most advantageous route to those who wish to travel to the city from the suburbs or farther afield. There is scarcely another city in the world which is so well favoured as London in the situation of its terminal stations. In New York, Berlin, and many other great cities, the main termini are located some considerable distance apart from the business centres, whereas in London we have such stations as London Bridge, Fenchurch Street, Broad Street, Liverpool Street, Cannon Street, &c., all situated on the very borders of the main business area. Then again, the Metropolitan and the Metropolitan District Railways are most admirably disposed from the point of view of acting as distributors in such cases as distribution is necessary, and in this work they are greatly helped by the deep tube lines. It is also extremely probable that in the near future petrol 'buses may form a most important branch of the distribution system, especially in the more crowded thoroughfares at present served by horse 'buses. The petrol 'bus can

FIG. 2.—VIEW OF CARS AND CONDUIT LINE, WASHINGTON, U.S.A.

circulate in thoroughfares where electric tramways would probably never be tolerated, and for this reason there is a most distinctive field before it, but at the same time it will never, under existing circumstances, supersede the electric tramcar. That there is room for both types of conveyance, is evidenced by the fact that horse 'buses have not been driven out of London by the electric cars, and where the horse 'bus can live, much more so should the petrol 'bus justify its existence.

and whilst giving very useful service they cannot be expected to solve the main traffic problem in our large cities, however much they may assist by filling in gaps in the general scheme of rapid transit facilities.

There is really no getting away from the fact that the motive power which must be relied upon for the main scheme is electricity, and it is in the electrification of the existing steam lines entering London, lies the only possible solution of the problem of adequately dealing

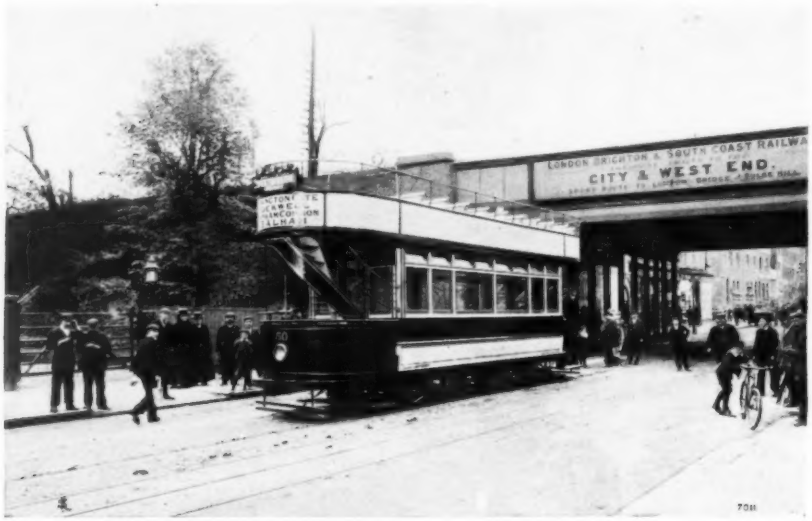


FIG. 3.—VIEW OF CAR, LONDON COUNTY COUNCIL CONDUIT LINE.

It is not the intention of this article to enter into or discuss the vexed question of the rival merits of petrol and electricity, but it may not be out of place to point out that petrol 'buses may find another large sphere of useful work in acting as collectors and distributors in those districts where the number of passengers to cater for would not warrant the expenditure involved in the laying down of electric tramways or light railways. Petrol driven vehicles form a more or less special type of conveyance, suitable for special conditions of traffic,

with the traffic question of this great city.

At the present day it is almost universally recognised that steam haulage is unable to fulfil the requirement of existing circumstances, and for some time there has been a general talk of adopting electricity in some form or other. But to decide to adopt electric traction and to choose what particular system shall be employed, are two totally different things, and the difference of opinion on the latter question is responsible for a great deal of the delay in the

general conversion of the steam railways to electric traction as far as their suburban traffic is concerned.

The correct system for operating electric tramways has by common consent been agreed to be the continuous current system at 500 to 550 volts, and this system is not likely to be superseded mainly on account of the comparatively small units operating over the lines, and the short distance over which the lines extend. In consequence of these two facts there is no incentive to attempt to use a higher voltage on the lines, and, therefore, the direct current motor is the most suitable that can be found for the work. Also there can be little doubt that the overhead trolley wire is superior to all other methods of disposing the conductor from which the supply of current is taken. The underground conduit system gives practically equally good results in operation, and in certain minor respects may have a few advantages over the trolley system, but the very heavy capital cost of the former makes its employment justifiable in but very exceptional cases.

The surface contact system has so far not been touched upon for the simple reason that in spite of its age, it is still far from perfect. It is not usually adopted at all except by private companies in cases where local authorities refuse permission for the use of overhead wires, and the heavy cost of a conduit system renders the only other practicable alternative out of the question.

Thus it would seem that the present methods of electric traction for tramways are not likely to undergo any radical changes in the immediate future. The chief opening for inventive genius in this direction would appear to lie in the discovery of a surface contact system comparable to the existing overhead trolley system in safety and efficiency.

When, however, we come to consider electric railways, we see that matters in this branch of electric traction are in quite a different state and that unanimity of opinion on the subject of the best system, is conspicuous by its absence. This is partially owing to the fact of there being two distinct types of railways which either are already electrified or may be electrified in the near future. On the one hand we have such lines as the Metropolitan and Metropolitan District Railways, and the various tube lines, on which the stations are only a very short distance apart, and upon which only electric trains, stopping at every station, operate. On the other hand we have the numerous steam railways radiating from the business centre of London, with stations somewhat farther apart than is the case with the former class, and over which lines, steam-hauled express trains as well as stopping electric trains, must travel. The reason for having to make provision for fast steam traffic as well as local electric services is because there is no immediate prospect of electricity replacing steam for long distance through traffic, and consequently it becomes necessary to provide for both.

For the former, or what may be termed the exclusively electric lines, the third rail system has so far been almost universally employed, and the results obtained have certainly been very satisfactory, as may be seen from the success of the Lancashire and Yorkshire, the North Eastern, and Mersey Tunnel Railways. Fig. 4 gives a general view of the electrified Lancashire and Yorkshire lines between Liverpool and Southport. But at the present day it has been widely recognised that the third rail system cannot be seriously considered when it becomes a question of electrifying the suburban lines running into such termini as London Bridge, Victoria, &c. Under such circumstances the use of a third rail and perhaps a fourth, cannot be contemplated for a moment, in view of the complication of the various tracks and the present difficulty of keeping in proper repair the permanent way. This task is quite hazardous enough as it is, and the men employed have quite enough to occupy them in avoiding the passing trains without having their attention still further occupied by the necessity of keeping clear of a charged conductor.

Then again its presence would add immensely to the difficulty of unloading materials for the necessary repairs of the permanent way, and would prove an additional source of danger in the event of a train becoming derailed, indeed, in such circumstances a bad short circuit and consequent fire might easily result.

It is, however, not only on account of the foregoing that the third rail system has been "weighed and found wanting." Just as the practical impossibility of many instances of installing a third rail has compelled engineers and scientists to seek for a system which would permit of the charged conductor being carried overhead, in the same way the urgent need for an increase in the working voltage has clearly demonstrated that the conductor *must* be carried overhead, if due regard is to be paid to the safety of the public and of the servants of the company. Thus the same conclusion is reached by entirely different paths.

FIG. 4.—ELECTRIC TRAINS ON THE LIVERPOOL AND SOUTHPORT SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY.

There is most certainly a very real need for some system which will permit of a higher voltage than is feasible with direct current motors. With the rapid acceleration which is demanded for successful service, a heavy electric train requires an input of from 1,500 to 2,000 horse-power at starting, or even more. With a line pressure of 600 volts this means a current of 1,700 to 2,000 amperes, and consequently the conductors which have to carry this current become excessively large if the losses are not to exceed due proportions; also the sub-stations have to be situated at comparatively short intervals along the line, because the enormous currents which have to be supplied to the trains can only be conveyed very short distances. The large number of sub-stations thus required not only of itself increases the capital expenditure necessary, but at the same time largely increases the amount of sub-station plant which has to be kept as standbys in case of accident, because the more the sub-station plant is split up, the greater the proportion of sub-station plant that is required.

The natural outcome of the realisation of the shortcomings and failings of the continuous current third rail system has been the development of the single phase system. The reason for turning to single phase rather than to any other system is fairly obvious. The necessity for carrying the working conductor above

ground would compel the use of high voltage, even if the benefits of the latter did not cause its adoption for its own sake, and higher voltage means abandoning the continuous current system. Then, again, if an alternating current is to be used, there is really nothing besides single phase to be used since the use of more than one overhead conductor per track is most undesirable. This proviso makes the three phase system very objectionable, but even if it were feasible to employ two overhead wires for each train, there would still be other reasons against the application of the three phase system for such purposes as operating on a congested suburban line. The properties of the three phase motor even with the "cascade" control are not such as to render it very suitable for such a service. The acceleration obtainable is not as good as with single phase, and there is little or no possibility of making up lost time in the event of a signal stop or other delay, and since these two qualifications are nothing short of vital importance where suburban traffic is concerned, the three phase motor is clearly not suited for the work.

The three phase system, if not practicable for suburban traffic, is still an interesting example of engineering ingenuity and ability. In the case of the Valtelina line we have a long distance railway with surface gradients and stations a long distance apart; acceleration is of no importance and the train service is small and there are no complications as regards junctions. This line has now been working for about three years and has given every satisfaction to the Italian Government who have now taken it over.

Obviously the fact of the single phase system permitting the use of high tension currents and needing only one overhead conductor, would not be sufficient to warrant its adoption for railway work if it did not embody the other qualities essential for successful service. But this is far from being the case, for the single phase motor, as perfected by modern science, may practically be described as possessing all the good qualities of the continuous current series motor, without any of its drawbacks, and at the same time having several advantages which the latter lacks. Chief among these should be placed the ability of the single phase motor to operate over low tension third rail systems, which can be done with perfect ease, and only necessitates making a few simple changes in the connections.

The single phase system has often been spoken of as experimental, but this is not by any means the case. At the present day there are several single phase railways in operation. In Germany the Allgemeine Elektricitäts Gesellschaft has constructed the Spindlersfeld line at Berlin, the Hamburg Beuchansa line, the Stubbai Thal line near Innispruck, and also the Borrinage line in Belgium; Messrs. Siemens have built the Ober-Amergau railway. Fig. 5 gives a view of this line. The General Electric Company of America has equipped the Albany and Ballstone and other lines, whilst the Westinghouse Company has sold no less than thirteen separate equipments to various railways, amongst which may be mentioned the Indianapolis and Cincinnati Traction Company and the Atalanta Interurban Railway. At the same time Messrs. Lahmeyer built a single phase traction motor, and the Maschinenfabrick Oerlikon have equipped single phase railways in Switzerland.

In the face of this evidence it is impossible to maintain that single phase electric traction is only in the experimental stage. Doubtless there is considerable room for improvement in the exact methods of application which have been adopted in the various cases, but that is only natural, and it is sure to be some time before a definite standard is reached to which all the railways will conform. But in the meantime sufficient lines have been equipped to demonstrate conclusively that the experimental stage has been passed, and that the single phase traction motor of to-day is a commercial reality.

The advent of the single phase motor and the consequent possibility of using

high tension alternating currents would appear to bring us a step nearer the electric operation of long distance traffic, but it is very doubtful whether electricity will ever be used for this purpose, anyhow for some considerable time to come, unless under certain special conditions. Thus for instance such a scheme might be quite feasible in a mountainous country where a large supply of water power was obtainable and coal expensive, but as far as this country is concerned the steam locomotive is certainly not likely to be ousted from its present position for this class of traffic.

The traffic problem, speaking generally with reference to large cities, is considerably complex, and probably to meet future requirements demands a very careful study of what has transpired in the past—and past history invariably shows that the demand for transit facilities increase as the means are provided. In other words, the public becomes educated up to making more journeys than formerly as soon as the requisite facilities are put forward for its use. Statistics very clearly show that the amount of journeying which goes on increase from year to year much faster than the population increases, and that can only mean that each individual member of the populace travels considerably more than either he or his predecessor did in former years. In New York it has been found in the case of the Manhattan elevated railway that the quicker and more frequent service which was rendered possible by substituting electricity for steam, resulted in an enormous increase in the number of passengers carried. The same thing will undoubtedly be experienced in London as soon as the present steam lines become converted.

This increase in the travelling propensities of the community is to be welcomed, and should be encouraged in every way. From the point of view of the health and physique of the nation it is infinitely preferable that the millions of city and town workers should spend at least some portion of their lives in the fresher and purer air of the suburbs. Fortunately there is a growing tendency to seek homes away from the immediate vicinity of London, and as a result the overcrowding in unhealthy districts stands a chance of being alleviated to a considerable extent by this means. The London County Council tramways are already doing much to rid London of its slums, and every year should see a definite improvement in this direction. The people are willing enough to live away from London itself, and if only the necessary means were provided to take them to and fro, hundreds of thousands of people would gladly move out to the suburbs and settle down there. The lack of good and cheap means of communication between the city and such districts as are available prevents them from acting according to their wishes.

As already pointed out earlier in this article, electric tramways do a great and good work, and in default of other means of transit, they have taken upon themselves work which is not really within their proper sphere of action, but they can never expect to fill adequately the position which should rightly be occupied by the steam railways entering London. The steam lines already carry an enormous amount of traffic, as is shown by the following figures which I quote from one of the articles on "Railway Economics," by the Hon. Robert P. Porter, which appeared in *Traction and Transmission*. The figures refer to the traffic upon the steam lines converging upon London, exclusive of main line traffic, and also exclusive of traffic *within* the area of London.

Name of Railway.	Number of passengers taken in and out of London. 1901.
1. Great Northern	34,000,000
2. Great Eastern	91,741,000
3. London, Tilbury, Southend	14,250,000
4. London, Chatham and Dover	29,159,000
5. South Eastern	28,645,000
6. London, Brighton and South Coast	27,262,000
7. London and South Western	30,000,000
8. Great Western 9. Great Central 10. London and North Western 11. Midland	18,000,000
Total	273,057,000

These figures most clearly show the important work which is being performed by the steam lines, even under the conditions which exist at the present day, that is to say, with a service which in most cases is neither fast nor frequent. This shortcoming in the matter of service provided is generally speaking not the fault of the various companies except in so far as the mode of propulsion used is out of date. In other words it is scarcely possible for these lines to maintain a more speedy and more frequent service than they are giving at the present moment. The majority of the lines are worked up to their utmost limit during the rush hours, and nothing short of increasing the number of tracks and providing more terminal accommodation would alleviate the trouble, if steam traction were the only system available.

But the advent of electric traction generally, and the single phase system particularly, has put a new complexion on the state of affairs. As mentioned above, one of the greatest difficulties with which railways have to contend is the restricted terminal space. It is just in respect to this trouble that electric traction has such a great advantage, because an electric train can run into a terminal station, receive its load of passengers, and run out again in a fraction of the time that would be occupied by a steam train under similar circumstances. This is due to the fact of the electric train being reversible, whereas the steam train has to be delayed on account of the shunting in and out of the steam locomotives.

Then, again, not only is the capacity of the termini increased, but the carrying capacity of the whole line is augmented. The number of trains that can be run depends mainly on the minimum headway which is considered safe—and electric trains, owing to their much higher schedule speed, can run at very short intervals of time whilst still maintaining a given minimum distance between consecutive trains. Thus, on this score alone, a far more frequent service can be given. But a still more important point is the ease with which electric stopping trains can be sandwiched in between express steam trains. Where express steam trains and

FIG. 5.—CARRIAGE EQUIPPED ON SIEMENS SINGLE PHASE SYSTEM, OBER-AMERGAU RAILWAY.

stopping steam trains are running promiscuously over the same set of metals, there must inevitably be a considerable waste of both time and space, since an express train must give a slow train a considerable start if no blockage is to occur before the end of the journey. In the same way a stopping train starting immediately after an express, and bound for the same destination, will not arrive until some considerable time afterwards, and the difference in the two times represents a period when the line, although comparatively free of traffic, is entirely useless. With electric stopping trains no such waste takes place, because of the high schedule speed that can be obtained. The schedule speed of the electric train can be made sufficiently good for the difference in running time between it and the express trains to be practically inappreciable in considering such lengths of line as would be used by both sets of trains. Consequently on this account alone the frequency in speed of the service can be enormously increased.

There is undoubtedly a great future before the suburban railways of London and other great cities of England. The traffic on these lines is already enormous as was shown before, and there can be no doubt that electrification will still further augment the number of passengers carried by them. The existing steam railways with an electrified suburban service are *the* solution of the traffic problem, and properly worked are quite capable of supplying the wants of the public. There has been considerable delay amongst the majority of lines in venturing upon the adoption of electric power, but it is satisfactory to know that England was the first to have a heavy steam line converted to electric traction just as she was the first to construct a deep-level tube-line. Now, once again she will be the pioneer of single phase electric traction upon a congested suburban system. The recent decision of the London, Brighton and South Coast Railway Company, of which the writer is the consulting electrical engineer, to experiment with the alternating current system, has excited wide interest, and the result of the trial should have the most far-reaching effects.

Automobile 'Buses *versus* Tramways.

By HENRY M. SAYERS, M.I.E.E.

THE recent appearance in the streets of London and various provincial towns of automobile 'buses in public service has been made the occasion of a considerable effusion of printed and spoken utterances on the subject of this article.

To a large extent the object has been controversial or political, the writers and speakers being principally concerned with the attack or defence either of tramways in general, municipal tramways in particular or the overhead electrical equipment which still excites the feelings of a remnant to whom it is unfamiliar.

Such political objects only obscure the engineering and economic facts which ought to decide the use of one or the other means of locomotion for public service in any particular case, and it is the object of this article to consider those facts in order to get to some general conclusions as to the relative values of the transit methods under consideration.

The primary and essential difference between the tramcar and the omnibus is that one runs upon the ordinary road surface and the other upon rails laid down in the road. All other essential differences derive and originate in this one. In some quarters the controversy has been treated as one involving the petrol engine and the electric motor. This is less than a half truth. There is no reason why the petrol-engine should not be applied to a tramcar, and it is a perfectly safe prophecy that if experience shows that either petrol, steam, or any other self-contained motor gives a marked economy over electric driving, the electric tramway motor will speedily disappear. On the other hand electric driving is not readily applicable to a vehicle not running on a fixed road. The storage battery method is commercially impracticable at present, and there is nothing in sight likely to alter that fact. Overhead wires have been used to supply current to electric 'buses, but double wires and trollies are necessary, the 'bus is tied to the wire and the device cannot be regarded as a success.

So it may be said that while any motive power available for a 'bus is available for a tramcar, electric power is not available for a 'bus. Neither is the cable system, but that is practically obsolete excepting where very severe gradients call for an elevator rather than a road vehicle.

It is not amiss to point out in this connection that steam, gas, and compressed air engines have all been used for tramway propulsion, and have all given way to electric driving wherever circumstances have admitted of the change, with great benefit to both owners and users of the tramways.

The discussion is therefore narrowed to the relative advantages and disadvantages to vehicles providing a public transit service of running on rails and running on the ordinary road surface.

In the main this is a question of economics and the method giving a required service at the lowest total cost should be preferred. There are, however, some considerations involving the convenience and safety of other users of the street which cannot be very well priced or treated quantitatively and no doubt these will appeal to different individuals with different degrees of force and give rise to varying opinions.

It is not necessary in a technical journal to dwell upon the advantages of a smooth rail over a more or less

irregular road surface. They have been known and utilised for centuries. Wooden beams, and stone slabs were used for the earlier tramways, which were mainly employed in mining and other districts where the transport of heavy materials was an important item in the cost of production. Stone tramways are of course met with on many steep hills in this country—Reigate Hill for example—and there is an Act of Parliament in existence authorising road trustees and authorities in Scotland to construct such tramways and to take tolls for their use.

The iron or steel rail gives the lowest tractive effort of any roadway at present known, and this is the principal advantage of the modern tramway, just as it is of the modern railway.

An eminent engineer is reported to have said recently that "laying a rail in a road is a confession that the road is imperfect." This is quite true, but the perfect road, as measured by the tractive effort standard is, to say the least, somewhat difficult to come by, and to maintain. To make a road surface all rail, or all equivalent to rail in low resistance and smoothness is hardly practicable and would certainly be very costly. It may fairly be said that no road surveyor or engineer obtains such a result to-day, and so long as roads have to be built to carry the varied traffic, horse drawn, mechanically propelled, humanly propelled, light and heavy, fast and slow, it seems impossible, apart from consideration of cost, to produce a road surface which can be called "perfect" for any one of them, much less for all. As a concrete example, the road of lowest resistance to self propelled vehicles with steel or iron tyres has a smooth surface of the same material, *i.e.* it is all rail. But clearly such a surface will not suit horses, rubber tyred vehicles or pedestrians. From these considerations it follows that the surface of a public highway is necessarily a

FIG. 1.—20 H.P. FOUR-CYLINDER MOTOR OMNIBUS, AS SUPPLIED TO THE GREAT WESTERN RAILWAY COMPANY.

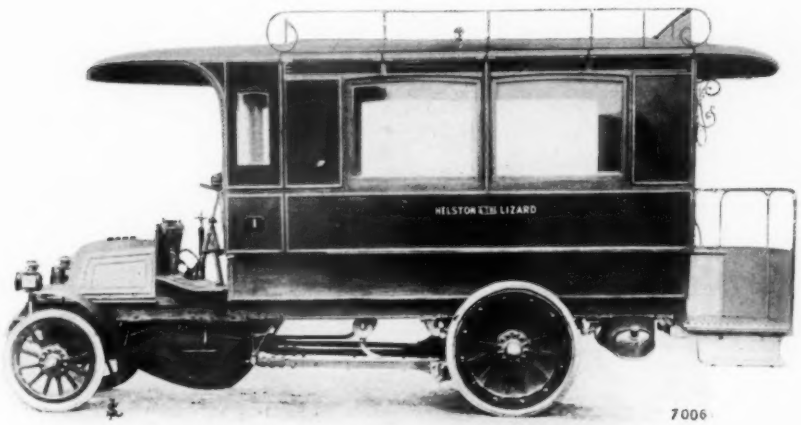


FIG. 2.—18 H.P. FOUR-CYLINDER MOTOR OMNIBUS, AS SUPPLIED TO THE GREAT WESTERN RAILWAY COMPANY.

compromise as regards its fitness for the various classes of traffic using it, and its excellence of construction and maintenance are severely conditioned by the funds available for the purpose.

The perfect road being thus unobtainable at present the tramway engineer seeks to provide one as nearly perfect as circumstances permit but having a total width corresponding to the wheel tyres of the special vehicles designed to run upon it. Thus for a double track, the special road is about 16 in. in width, including the grooves and guards, and it will at once appear that to provide this small width the cost must be much lower than to provide an equally good surface for the whole width of a road.

The tractive resistance on a level straight tramway track in average condition for speeds up to twenty miles per hour is about 22·5 lbs. per ton, or very closely 1 per cent. of the weight. Pneumatic tyres on setts, offer a tractive resistance of about two and a half times this, or say 60 lbs. per ton; but the resistance rises rather rapidly with the speed and increases rapidly with rough or muddy surfaces. On macadam the resistance is higher. On asphalt or wood, clean and in good condition, it will probably be lower, but authoritative measurements are not available. Iron tyres give higher figures.

In what follows it is assumed that the solid rubber tyres in general use on motor 'buses have as low a tractive resistance as pneumatic tyres. This is undoubtedly somewhat too favourable, but sufficient data is not available for a closer estimate.

Particulars of experiments on this subject will be found in the report of a committee read before Section G of the British Association in 1903.

If only straight level roads had to be considered, this great difference in the amount of propelling power required would leave the omnibus a very small chance in competition, but the necessity of providing for gradients and curves reduces the proportional difference. Lifting a ton any given number of feet taxes a definite amount of energy irrespective of road resistance. Hence a rise of one per cent. doubles the tractive resistance on a tramcar, making it, say 45 lbs. per ton; but on a pneumatic tyred vehicle the resistance will rise from say 60 lbs. to 82½ lbs. per ton, so that as the gradient increases the ratio

FIG. 3.—MOTOR OMNIBUS BY THE MOTOR CAR EMPORIUM CO. LTD.

of power expended by the two vehicles becomes more nearly unity. The effect of curves is probably greater on the 'bus for equal speeds, because the lateral pressure between tyres and road must be the same per ton, and the coefficient of friction between rubber tyres and road material is pretty certain to be higher than between wheel flanges and rail guards. On curves of very short radius the tramcar may be at a disadvantage, owing to the fixed wheel base being too long with consequent grinding of rails and flanges. But in such cases speeds are necessarily low, and although the energy consumption is increased, the power to be provided is not affected. The total length of such curves is usually a very small proportion of total route length, and curve resistance is rarely a factor which need be specially considered in the provision of driving power.

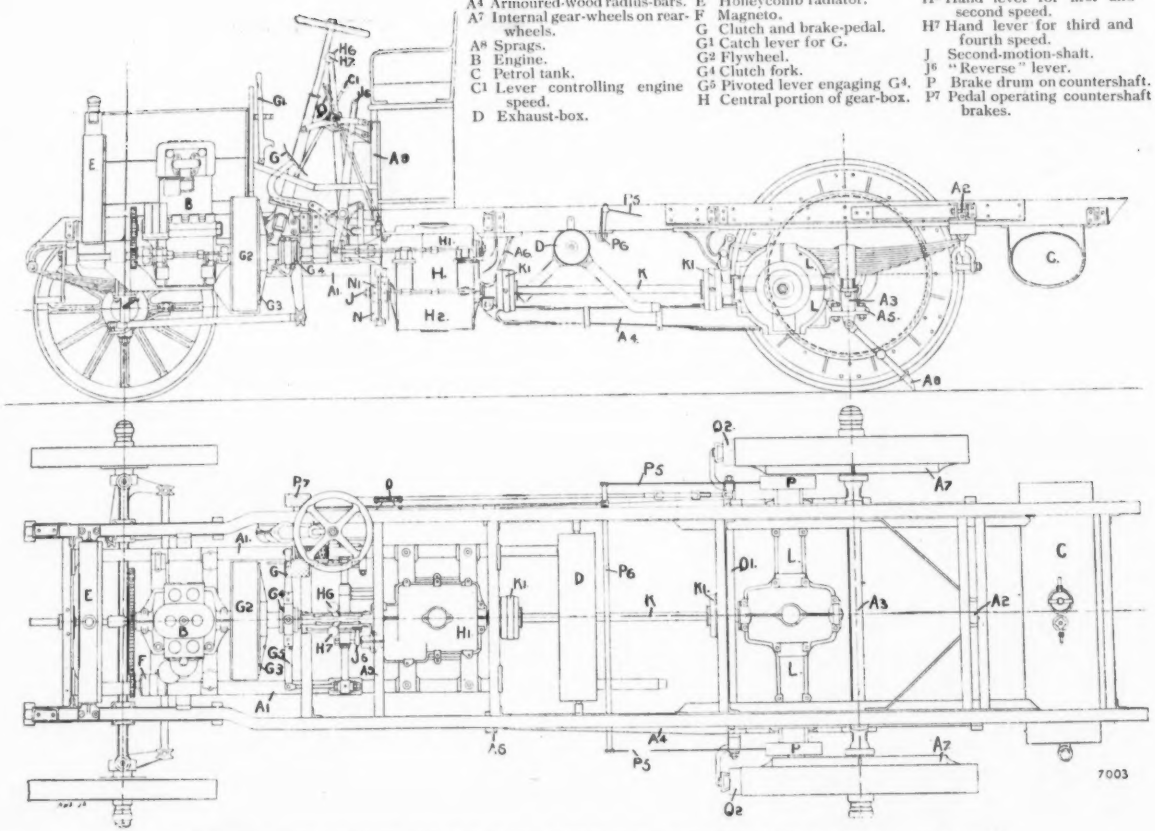
The average and maximum amount of power needed to drive a tramcar under given circumstances is now pretty well known, thanks to the wide use of electric propulsion and the ease and accuracy with which electric power can be measured, both at the generating station and on the car itself; and from these known figures it is possible to approximate the power needed by an omnibus.

There is necessarily a wide difference between the average power expended and the maximum power needed. The one figure affects working expenditure mainly, the other figure is some measure of the capital expenditure and of the standing charges which it entails. For comparative purposes the differences in cost due to different methods of generating and applying power must necessarily be brought into account.

On a tramway of average character in respect to curves and gradients, say a little harder than the Glasgow tramways taken all over, but easier than those in the Potteries, in Sheffield or Huddersfield, the actual power delivered to a car weighing about 11 tons and making an overall speed of seven miles per hour, is about 7 h.p., or $5\frac{1}{4}$ kilowatts. The horse-power corresponding to the straight level road resistance at that

TABLE OF REFERENCE LETTERS FOR FIGS. 4 AND 5.

A4 Armoured-wood radius-bars.
A7 Internal gear-wheels on rear-wheels.
A8 Sprags.
B Engine.
C Petrol tank.
C1 Lever controlling engine speed.
D Exhaust-box.
E Honeycomb radiator.
F Magneto.
G Clutch and brake-pedal.
G1 Catch lever for G.
G2 Flywheel.
G4 Clutch fork.
G5 Pivoted lever engaging G4.
H Central portion of gear-box.
H6 Hand lever for first and second speed.
H7 Hand lever for third and fourth speed.
J Second-motion-shaft.
J6 "Reverse" lever.
P Brake drum on countershaft.
P7 Pedal operating countershaft brakes.



FIGS 4 AND 5.—SIDE ELEVATION AND PLAN OF THE MILNES-DAIMLER 3-TON CHASSIS (WITH TWIN-CYLINDER ENGINE).

speed is 4·75. A rubber-tyred vehicle on a good road, if of equal weight, would require 12·7 h.p. at the wheels, or a total horse-power at the motor or engine, assuming 70 per cent. overall efficiency, of say 18 h.p.

These figures are comparative for equal speeds and equal weights. Of course there is no motor 'bus in use weighing 11 tons, but weight for weight on such an average road as assumed in the foregoing, the relative expenditure of power as between tramcar and motor omnibus will be of the order given, *i.e.*, as 7 to 18. At higher speeds the disproportion will be greater, because the road resistance augments more rapidly for the omnibus than for the tramcar.

To compare the working costs of the two vehicles so far as power is concerned, regard must be had to the seating capacity per ton of the loaded vehicle, and to the cost of the power as delivered to or generated on the vehicle. As regards the first point, the dead weight per seat of the omnibus will generally be below that of a tramcar, which is an advantage so far as power consumption, the wear of tyres, and effect on roads are concerned, but a disadvantage of a grave character when durability and repair costs are considered. On this point it may be noted that experience has led to a continual increase in the dead weight of tramcars, the increased power consumption being of insignificant value compared with the saving in repairs and the increase of durability.

There is no reason why a tramcar should not be made as light in proportion to its seating capacity as a motor omnibus, but it is quite certain that it would not be improved as an economical machine by the change.

To price the relative power expenditure many circumstances have to be taken into account. Inevitably the mind compares the cost of electric power delivered to the tramcar as against the cost of power developed by petrol on the omnibus; but such a comparison is not between like things. The true cost of the electric power should include the capital charges, cost of repairs, and the renewal fund upon the whole of the generating and distributing machinery; but the capital charges, repairs and renewal charges on the petrol engine and gear cannot well be separated from those on the vehicle taken as a whole, and the figures usually given for the power cost of petrol cars really cover only petrol and lubricating oil.

A very fair average covering price for electrical energy delivered to the car is $1\frac{1}{2}d.$ per unit, but there is a wide range in present practice, all the way from $1d.$ to $4d.$, and in considering any particular case, the local circumstances affecting this price must be duly weighed.

Taking the average road above assumed, the 11-ton tramcar will consume ·75 units per car mile, which at $1\frac{1}{2}d.$ will cost $1{\cdot}125d.$ This is obviously about $\cdot 1d.$ per ton mile, and, as such a car will seat 56 passengers, it works out at $\cdot 02d.$, or $\frac{1}{50}$ of a penny per seat mile.

A double decked petrol omnibus carrying 36 seats will consume about 1 pint of petrol per mile run, which at $10d.$ per gallon costs $1.25d.$ and works out to $\cdot 035d.$ or 1-29th of a penny per seat mile.

As just stated, the comparisons are not between like things, and are not a measure even of the cost of power, much less of the total cost in the two cases, but so far as they go they show that weight for weight the use of a tramway saves a very large amount of power, that electric power delivered to a tramcar costs less per seat-mile than petrol power generated on an omnibus, even though the electric costs are loaded with the capital and other charges on generating and distributing plant, whilst nothing in this respect is charged for the petrol engine and transmission gear.

Before passing to other matters, it is as well to consider for a moment what becomes of the additional power consumed by the omnibus. As the only difference between the two cases is in the character of the rolling surfaces, this power must be expended on the rolling contact, in friction or in detrusion and deformation of one or both surfaces.

The result is manifest in the cost of tyre up-keep, and in the complaints of road surveyors. It must not be forgotten that the wearing of the road is just as much a part of the cost of running motor 'buses as the wear of tyres.

To take the tyres alone there seems fairly reliable evidence that the cost of upkeep of a set of 'bus tyres is from 2*d.* to 2½*d.* per mile run. It has been publicly stated that a firm of tyre makers will take maintenance contracts at £100 per 10,000 miles, and this works out to 2·4*d.* per mile. It is very significant that the destructive effects of the wasted power should exceed the cost of the

not amount to 1*d.* per car mile, including the motors and electrical equipment.

These facts indicate what an enormous advantage the tramway rail gives; not only is much power saved by its use, but the power that is wasted by the road vehicle is spent in destroying the vehicle, as well as the road, and to make good that destruction costs a great deal more than the power itself.

Tramcars and omnibuses have been running for many years under conditions more easily comparable than those of electric propulsion on the one hand, and petrol engine propulsion on the other. Both have been horse-drawn, and in

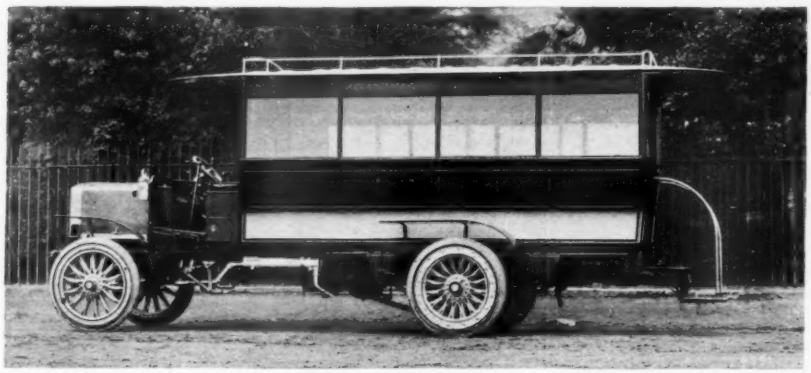


FIG. 6.—A THORNYCROFT SINGLE DECK MOTOR OMNIBUS.

whole power expended, and shows how very imperfect is the relation of a rubber tyre to an ordinary road surface. They may be regarded as two parts of a machine of mutually unsuitable materials very badly fitted. Rapid and costly wear is the inevitable consequence. Contrast with the tramcar wheels emphasises this. A set of chilled iron car wheels will run 30,000 miles. The whole cost of rewheeling a car, including new wheels, dismantling axles, pressing wheels on and off, and replacing axles is under £10. But taking that figure the cost is just one-thirtieth or ·08*d.* per car mile. In fact the whole cost of maintenance and repairs of such a tramcar as has been considered herein does

London they have been working side by side. Some of the figures from the London tramway and omnibus companies' accounts illustrate very forcibly the advantages of the railed track, and may be set out here as being well ascertained and published facts, taken from the reports of the respective companies to their shareholders, for a certain half year taken at random.

	Omnibus Company.	Tramway Company.
Vehicle miles run ...	16,272,202	7,318,017
Passengers carried ...	106,116,283	70,701,915
Horses in stock ...	17,060	6,380
Vehicles, miles per horse	954	1,147
Passengers, per vehicle mile ...	6·52	9·66
Passengers, per horse	6,220	11,082

So that on a tramway a horse is worth 20 per cent. more as regards vehicle miles and 78 per cent. more as regards passengers carried; or five horses on a tramway will do the work of nine in omnibuses.

The operating costs of the two concerns show what this difference means in maintenance as well as running expenses.

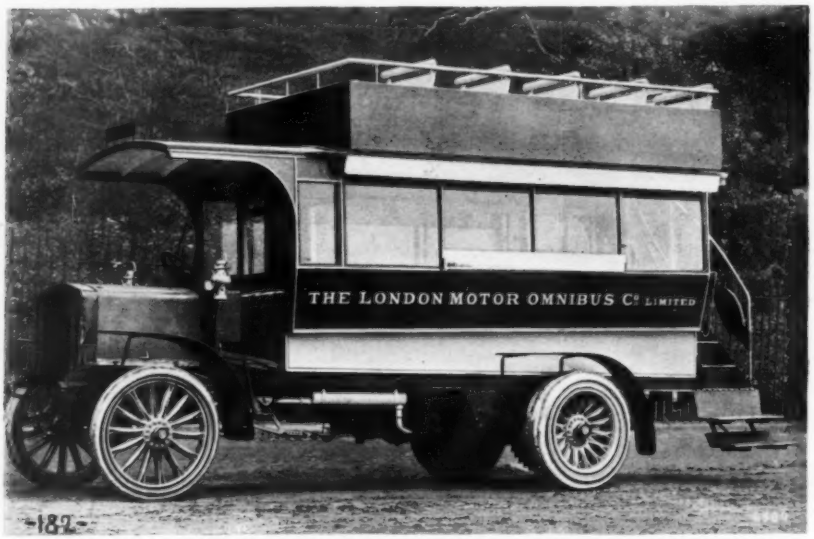


FIG. 7.—A THORNYCROFT DOUBLE-DECK MOTOR OMNIBUS.

COSTS PER VEHICLE MILE.

	Omnibus Company. d.	Tramway Company. d.
Horsing costs	3·79	2·49
Horse renewals	·62	·48
Vehicle maintenance	·525	·235
Total of above, per vehicle mile	4·935	3·205

COSTS PER PASSENGER.

Horsing costs	·580	·260
Horse renewals	·095	·050
Vehicle maintenance	·080	·024
Total of above, per passenger	·755	·334

How much the relative amounts of these figures must be altered to adapt them to mechanical traction in both cases cannot be stated at present, because there is not sufficient experience with the motor driven omnibus, but on the tramway side it is already well established that total working expenses, exclusive of renewals of track, but including all current repairs, need not exceed 6*d*. per car mile, and that earnings of 9*d*. per car mile suffice to cover all reasonable capital charges and provide for renewals if the traffic will yield that income on, say, a 10-minutes service. It is generally held that traffic not justifying a service at a less interval than 20 minutes will not pay the capital charges; and also that earnings in excess of 12*d*. per car mile indicate that an insufficient service is being run. Naturally both these figures are subject to the special circumstances of any particular line, but they serve to indicate what the motor omnibus has to accomplish in order to show economic superiority.

It is at present impossible to follow out the working costs of motor omnibuses, and to establish reliable figures in comparison with the well ascertained costs of electric tramways many of which have been working for over ten years, one or two even for twenty years in this country. It is not indeed the purpose of this article to make such a comparison, but rather to point out what elements have to be compared, and how the different elements of costs are interrelated.

The figures of motor-'bus working costs published in various quarters are no doubt given in good faith, but cannot be taken as very reliable. It may be fairly expected that when working on a large scale, organisation and experience will lead to marked reduction in certain items of expenditure. On the other hand it is probable, and quite natural, that the manufacturers are carrying out a certain amount of maintenance or replacement under guarantees, or at contract prices which do not represent the actual cost. In any case it will take several years to ascertain the true durability and proper allowances to be made for maintenance and renewals (or depreciations), and the most economical annual mileage rate and earning capacity of such vehicles.

The principal point that can be made against the tramway is the capital expenditure on the track, or permanent way. To this expenditure certain omnibus advocates add that for the electrical generating plant equipment generally. As above shown this is not essentially tramway expenditure. It is merely a question of which is the most advantageous power to employ. If electricity saves enough over petrol or steam it will continue to be employed. If not it will be displaced. The issue is therefore narrowed to the cost of the track, and the question whether the working savings due to the rail laying will exceed the capital, maintenance, and renewal charges involved.

The cost of laying a mile of double tramway track with the best materials and workmanship, under average conditions is about £12,000. This cost includes paving with granite setts or hard wood blocks between the rails, 4 ft. clearway between the tracks and 18 in. on each side outside them—a width overall of about 17 ft. or a nett width of paving of about 15 ft. 8 in. The cost of this paving material is not, properly speaking, part of the cost of the tramway. When all tramways were horse tramways the case was different, but it is obvious that mechanically propelled tramcars do not need, and do not wear the paving. On the other hand the paving material in a busy thoroughfare wears down faster than the rails, which tend to project and become dangerous to other traffic. It is not therefore altogether unfair that the tramway undertaking should be charged with a part of the cost of paving maintenance. How much is a debateable point, and whatever strict equity may require, it has to be borne in mind in reckoning the total cost of a tramway service that such paving maintenance is a relief to the rates, in so far as a smaller amount of road surface has to be maintained from the public funds. Of the £12,000 per mile expended about £2,300 represents the cost of rails, fastenings and platelaying and the cost of renewing this wearing part, including labour and taking credit for scrap material will be about £2,700, the lifting and reinstatement of the paving accounting for the increased cost. The annual charge on this account will be made up of two items, first, current repairs to keep it in running order, secondly, the renewal fund for replacing it at the end of its useful life. The useful life of a tramway rail is not a definite term. Much wear may be occasioned by the ordinary road traffic, and cases are on record where tramway rails have been worn out in about fifteen years by ordinary road traffic alone, no other use having been made of the track. A fair average figure will be fifteen years, but of course the frequency of the tramway service and the amount and character of other traffic on the road will affect it through wide limits.

Taking fifteen years, however, the

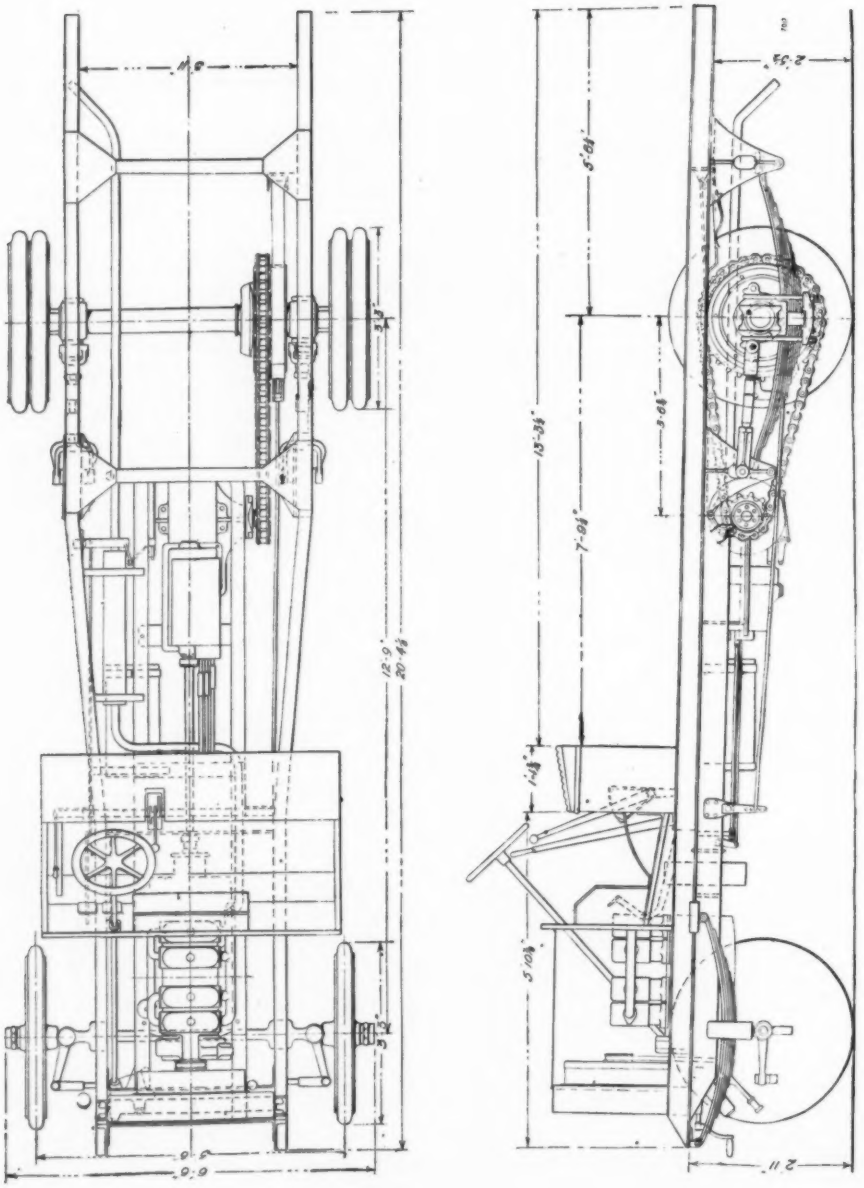


FIG. 8.—GENERAL ARRANGEMENT OF THORNYCROFT CHASSIS.

permanent way will cost for repairs and renewals:—

	£
Current repairs, 2 per cent. on £2,300 ...	46
Renewal fund for relaying at end of 15 years, 5·3 per cent on £2,700	143
Total annual charge for rails only ...	£189

In addition to this item there are charges for interest on the original construction and for the upkeep of the paving.

This latter item varies with the actual material used and the amount of traffic on it. If the tramway service is very heavy it should keep other traffic off, and the wear of the paving should be low. There is not enough experience on record to indicate the magnitude of this effect. Taking a bad case, assume that the paving needs renewal with the rails, and that the material costs 10*s.* per sq. yd. The cost of lifting and relaying is included in the renewal of rails. Ten shillings per sq. yd. for one mile of a track 15 ft. 8 in. in width amounts to £4,420 nearly enough. Hence the yearly cost under the two heads just mentioned amounts to:—

	£
3 per cent. interest on £12,000	360
Renewal fund for paving at end of 15 years, 5·3 per cent. on £4,420	234
Total	£594

Adding this to the permanent way charge gives a total of £783 for interest and renewals on the whole of the roadwork.

What this will amount to per car mile evidently depends upon the service run. A moderate figure for town work is a five minutes service. Taking this as for sixteen hours per day, and 340 days per annum (figures which allow for the less frequent service at the ends of the day, and on Sundays) gives an annual amount of 130,000 car miles upon the mile of track, upon which the annual charge of £783 averages 1·45*d.* per car mile. It is important to notice that of this annual charge £360 is independent of the amount of wear, and therefore of the amount of traffic; £189 is the only part directly depending upon the tramway traffic, and the balance of £234 is likely to diminish with increased tramway traffic. Hence it is impossible to say that the charges on the track represent any fixed amount per car mile. With a heavier service the charge per car mile will diminish. With a less service the charge per car mile will increase. This explains the statement made above, that a less frequent service than a car every twenty minutes will not be remunerative, *i.e.*, the capital charges per car mile swallow up the difference between working expenses and receipts.

It also partly explains the other statement that when receipts exceed one shilling per car mile a quicker service should be run, because the track charges per car mile diminish with more frequent service and a larger nett revenue may be earned with smaller gross receipts on a larger number of car miles.

It may be noted that where a service of less frequency than five minutes will suffice, a considerable amount of capital and consequent charges may be saved by laying a single line with loops at proper intervals. The wear on the rails will then, of course, be that due to the double service on the single line, and the maintenance and replacement of points and crossings has to be reckoned with

It will be seen from this very incomplete statement of some general principles of tramway economics that while the question of what a tramway will cost, what it will earn, and whether it will pay, depends upon a considerable number of variables, experience and judgment applied to the circumstances of any particular case will give a reasonably approximate answer.

Adding to the running expenses of a tramway the proper amount for the track capital charges will give a sum per car mile which has to be compared with the total cost of running a motor omnibus service of the same earning capacity.

It is abundantly evident that seat for seat the motor omnibus costs more for power, and more for maintenance, than the tramcar. Supposing that the motive

power is the same in each case, the tramcar will cost less to engine, seat for seat, it will cost less for wheel maintenance; and judging from experience it will cost much less to maintain and renew, in respect both to mechanism and body work. This last point is of course due to the superior smoothness of running, and greater solidity of construction of the rail borne vehicle.

Finally then the economic question resolves itself into this. For any particular route with given conditions will the capital and renewal charges on the track exceed the saving in working, traffic, and maintenance expenses as against those of an equivalent motor omnibus service.

As a very rough general answer one may hazard the suggestion that, where one vehicle every thirty minutes or less frequently will meet the public requirements, the motor omnibus will be the better. On country roads where track construction and maintenance is less costly than in towns it is probable that the tramway is superior for any more frequent service, but for town districts twenty minutes is about the limit of remunerative tramway operation.

It will be obvious that anyone applying these remarks as dogmatic truths may fall into grievous error.

In the foregoing remarks no mention has been made of rates. Tramways are rated, and assessed on a basis which is generally considered inequitable by tramway people. But though this payment of rates is an important consideration for a tramway company or department it does not affect the total cost of the tramway service to the whole community. It affects the distribution of the cost, to the prejudice of the tramway passengers, and possibly the shareholders, where a company works the tramway; and to the advantage of the ratepayers. It is therefore in effect a tax upon tramway passengers and owners but is not truly a part of the cost of tramway working.

As between private owners of tramways and of competing vehicles using the highways, it is grossly inequitable.

As the method of assessment has the effect of making the rates an income tax, it cannot be even roughly expressed as a charge per car mile.

It should be pointed out that part of the cost of an omnibus service falls upon the rates, in consequence of the wear of the road surface. This gives another apparent financial advantage to the motor omnibus, which is to that extent rate supported, even when privately owned. What this road maintenance may come to it is quite impossible to say at present. Road surveyors all over the country aver that the ordinary motor car is highly destructive to roads, but it is only fair to point out that the evidence mainly relates to macadamized roads. It seems possible that on wood, asphalte, and granite the damage may not be so serious. There is, however, the patent fact that tyres are destroyed at a rapid and costly rate, and there must be some reciprocal effect on the other member of the pair. Road materials are generally harder, and very much less costly than tyre materials, so that the money value of the damage is doubtless much less. Horsed omnibus traffic is very destructive to paved streets, but some of the wear is evidently due to the iron-shod quadruped, especially where he digs in his toes on starting his load, and it cannot be argued that the motor bus will do more harm. Time will show!

Whatever the amount, in reckoning the total cost to a community, of an omnibus service, this portion which falls upon the ratepayers must be added to the apparent cost, and in making a comparison between the omnibus and the tramway service it must be remembered that tramway costs, as usually reckoned and stated, include the maintenance of the track, part of the maintenance of the ordinary road surface, and the payment of rates; whilst the omnibus costs as usually stated omit the maintenance of its road. Of course the effect of these considerations will vary according to whether true economic results, or dividends, are the immediate objects in view.

There is undoubtedly a great field of usefulness for the motor omnibus where no question of rivalry with tramways can arise. The carrier's van is still the only means of public conveyance on many thousands of miles of English roads—and there are people and places who have not even so much convenience. In many market towns rows of these vans may be seen on certain days of the week, loading for journeys of up to thirty miles in length made at a pace of about five miles per hour. The passengers travelling by them must have strong incentives and no choice of means.

On these roads the automobile might spread a strong counter influence to the "depopulation of rural England," and find a remunerative and growing business. From this extreme to the scattered plutocratic suburbs of some of the large towns where no heavy service is needed provides a large sphere of usefulness where no rival need be feared. Beyond this sphere, which may be called the natural economic range, the prejudice of many worthy folk, and selfishness of others less worthy, have found it easy to turn the Tramway Act of 1870 into a means of keeping tramways out of many districts where they would have been and may yet be a public benefit. In such districts the motor omnibus may find great opportunities. It may indeed help to break down prejudice, and so become a forerunner of its supposed rival. If so, its great advantage of mobility will enable it to move on to other fields and help to feed its supplanter.

In truth, there is no real rivalry between the two modes of transit. Each has its place, and each should be able to meet particular public needs at remunerative tariffs. The omnibus horse, indeed, will probably disappear before the horseless 'bus at no very distant date, but until there is a revolution in road making, those two steel bars will keep their place.

There has been no opportunity in these pages to examine the objections to tramways on the score of danger and inconvenience to other traffic on the road. These objections are most difficult to express in any quantitative way. No doubt a greasy rail-surface is a danger to a cyclist crossing it whilst turning, or running on to the groove in the dark. To a smaller extent other rubber-tyred and narrow-tyred vehicles occasionally meet with mishaps from skidding or catching on the edge of the rail. A rotten wheel hub sometimes comes to sudden smash when its driver tries to turn off the rail quickly. But every form of street traffic entails some danger and inconvenience to all other users of the highway. It does not seem that any use of the highway can provide such facilities at so small a cost in inconvenience as the tramway does. Its capacity for passenger carrying is enormous. A double track occupying 16 ft. in width of roadway can carry at least 12,000 passengers each way per hour, leaving ample clearance between the cars. A considerably heavier service than this is carried during the "rush" hours on such lines as the Broadway and the Brooklyn Bridge, New York, and it does not seem possible that any such number could be handled on equal occupation of street space by any vehicle not confined to definite tracks, or that any street of ordinary width would afford room for other traffic if such a service were carried on by free vehicles. The advantage of "overtaking power" so much dwelt on by certain motor-'bus advocates, involve distinct dangers of collision only too familiar to the cyclist in busy streets, and assumes a considerable amount of room to spare in the street. It seems undeniable that the greatest capacity of any given street can only be realised by confining vehicles rigidly to definite tracks according to their direction and speed.

The tramcar is so confined and assists to guide other vehicles. It thus relieves street congestion by its unrivalled carrying capacity in relation to space occupied, and also by compelling stricter observance of the rules of the road by other traffic. So far as the motor-'bus has a superiority of speed over the

tramcar it is merely an artificial and transitory effect of legislation. Speeds will be levelled up and down, and the motor-'bus will have played a useful part in the process.

The progress made in adapting the motor-omnibus to the requirements of various services promises well for the utilisation of the opportunities that offer. Those who have watched developments know that great ingenuity, perseverance, and much money have been expended for many years past in making the motor-omnibus a practicable vehicle. Having succeeded in convincing the very experienced and naturally sceptical London omnibus-owners of the merits of the new vehicle, the adaptation of body and seating capacity to particular services is mainly a matter of coach-building and upholstery. The legal restrictions on weight, and perhaps the consideration of the weight it is wise to put on two axles as well as the gradients and curves to be negotiated naturally affect this part of the vehicle, but we are able to show by the accompanying illustrations that a considerable variety of accommodation and appearance is already available. Figures 1 to 3 are vehicles supplied for various purposes by the well-known Milnes-Daimler firm. One of these has 20 h.p. engines, the other 18 h.p., both being four-cylinder, which for free starting, balancing, and quietness are much superior to two-cylinder engines. The rated horse power is developed in each case at 800 revolutions per minute. The difference in cylinder dimensions is small; the 18 h.p. being 100 mm. by 130 mm., the 20 h.p. 105 mm. by 130 mm—say, $3\frac{15}{16}$ in. and $4\frac{1}{8}$ in. by $5\frac{1}{16}$ in. stroke.

The engine governing is effected by throttling the mixture, and the valves are positively actuated. These two features make for reliable action and some economy in fuel.

The change-speed gears give four speeds forward and one reverse, the flexibility of the motor gives some range between, and it is claimed that any speed from one to twelve miles per hour can thus be obtained.

There are three brakes, acting respectively upon the first intermediate gear shaft, brake blocks on back road wheels, and on each differential cross shaft.

The whole of the control gear is disposed in the handiest way, and much consideration has been given to the requirements of driving in traffic, stopping, and starting to order. The long wheel-bases, 12 ft. 7 in. in the 20 h.p. frame and 10 ft. 6 in. in the 18 h.p. frame, conduce to steadiness of the body and ease of turning. Observation of the running of the 20 h.p. frame, fitted with the thirty-six passenger double-decked body, only suggests the criticism that it is somewhat under-engined for any but a flat road, but it may be that the general greasiness of the Westminster Bridge approach has been the difficulty rather than want of power. These 'buses have solid rubber tyres, double on the driving wheels.

Figures 4 and 5 illustrate the 20 h.p. chassis, but Fig. 5 is from a drawing showing a two-cylinder engine instead of the four-cylinder engine used on the 'buses.

The mechanical details of these vehicles are extremely well thought out and worth study, but it would take a long article to describe them, and no doubt the makers will be glad to supply information to those interested, as they very kindly did to the writer.

Messrs. John Thornycroft & Co., Limited, are well known for their pioneer work in this direction, and have been good enough to give particulars of a 'bus chassis intended to carry a double-decked omnibus body seating thirty-four passengers. Figures 6 and 7 represent a single and double-deck 'bus respectively, built by this firm, and Fig. 8 gives the general arrangement of the chassis.

The rating of the four-cylinder engine is 24 B.H.P., the speed 900 revolutions per minute, the cylinders $4\frac{1}{4}$ in. diameter by 5 in. stroke.

It is unnecessary to say that reliability has been thoroughly studied in the engine details. Low tension magneto

ignition is fitted in both this and the Milnes-Daimler engine, which is an interesting development. Forced lubrication is carried throughout.

Four forward speeds, one reverse, and engine acceleration provide a range of from three to fourteen miles per hour. The car is stated to be capable of surmounting a gradient of one in eight.

Figure 8 will explain better than many words how convenience and prompt action in driving have been provided for.

Two brakes, one actuated by a pedal acting on the countershaft; the other a screw down acting on a drum on the back axle are provided.

The wheels have solid rubber tyres, twin on driving wheels. This feature seems highly successful in combatting the temptations to skid so liberally afforded by London mud.

The examples illustrated and very inadequately described have been selected to show that the process of adaptation is well advanced, and that any reasonable needs can be met. They are by makers well-known as pioneers, who have been good enough to supply the information, and have the writer's best thanks. Undoubtedly there are other vehicles as worthy of notice. The author particularly regrets that he has not been able to get any particulars of steam omnibuses. It is well known that certain firms have some successful patterns in use, and there seems good reason to suppose that they may prove better fitted for certain kinds of work than the petrol engine. The steam omnibus is far and away the oldest, and if it had not been choked by Parliament, road traffic and road surfaces would be very different from what we have to tolerate now.

Steam and Petrol for Transport and Locomotion.

By C. C. LONGRIDGE, M.I.Mech.E.

A WRITER* on the pros and cons of heavy transport enumerates twenty-one advantages of the motor over the horse-drawn vehicle, and the like number, over the fixed track, tram or railway car. Whether all the advantages claimed are realised is of scholastic rather than practical interest. It is sufficient to accept the indisputable fact that, given certain conditions, steam or petrol vehicles have beaten all rivals. The relative extent to which the two agents are entitled to claim participation in the victory is the question now before the reader.

* J. W. Roebuck, *Autocar Journal*, Industrial Section, March 18th, 1905.

In one field—that of the light commercial van and the pleasure car, petrol may safely be styled paramount. But in another—that of the heavy commercial, and of the large public service vehicle steam disputes precedence. Purely as heat engines, internal combustion motors are admittedly superior to steam engines. But thermal efficiency is only one factor. Other, and in their complex, perhaps, more important points, are the relative cost of fuel, of repairs, of maintenance, questions of durability, of driving skill required, of fire risks involved, &c.—all of which enter into and complicate the issue.

To analyse and define the present position of steam and petrol, we may

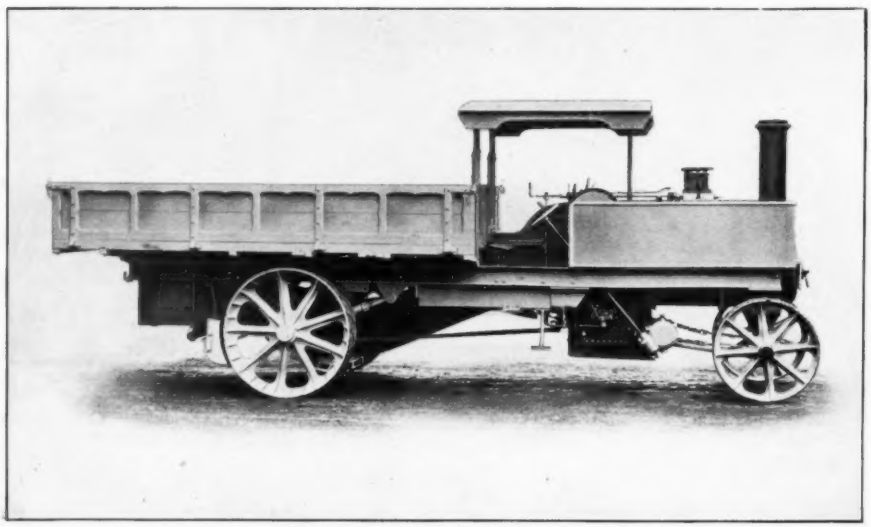


FIG. 1.—FIVE TON STRAKER STEAM WAGON.

FIG. 2.—THORNYCROFT PETROL ENGINED TRACTOR.

consider both in reference to : (1) Goods transport ; (2) passenger locomotion ; (3) special purposes ; (4) marine work.

1. Steam v. Petrol for Goods Transport.

This section we divide into—(*a*) Heavy Goods Transport ; (*b*) Light Goods Transport.

(*a*) *Heavy Goods Transport.*—For this service, tractors and wagons or lurries, with three to eight ton loads, are used, with or without trailers. It is here that steam finds widest application. Obviously the conditions are favourable. The deliveries are chiefly continuous, full-load runs. There are no intermittent halts, during which fuel and water are consumed to no purpose. The vehicles themselves are little affected by the extra weight of boiler, fuel or water. In fact, weight adds to the tractive power ; and, the pace being slow, it does not, even with iron tyres, result in road shocks and strains that seriously affect the stalwart steamer. Again, the action of the steam engine is reliable, its parts are substantial, and its range of power such as to eliminate or to minimise the necessity for change speed gear. It has, moreover, a large reserve power for emergencies,

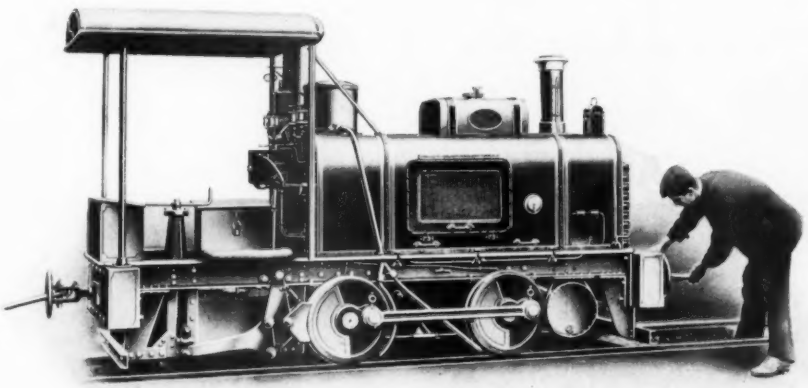


FIG. 3.—PETROL TRACTOR BY THE WOLSELEY COMPANY.

its fuel is cheap and easily obtainable, and the sources where drivers can be obtained and repairs can be executed are numerous. For these reasons, steam has, over this field, a hold that petrol has not, so far, materially weakened. Fig. 1 shows a Straker five ton steam lurry, built for the iron and metal trade. The most vital parts of the steam vehicle are the furnace, boiler, condenser, and engine. Until recently, the vertical fire or water tube type of boiler prevailed since it

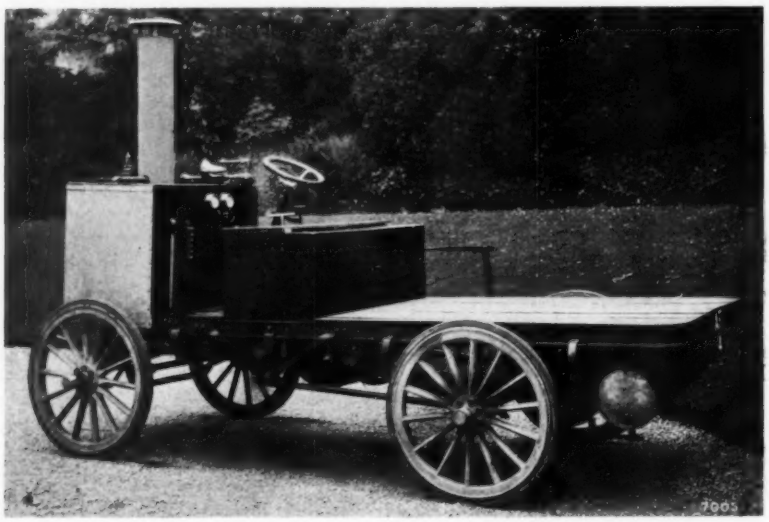


FIG. 4.—BICKFORD 30 CWT. STEAM WAGON.

removed the risk of dry exposed tubes on steep gradients. But the variations of water level or gradients is now met by such devices as raising the outer fire-box casing above the top of the boiler barrel, &c.; and Messrs. Thornycroft, Straker and Squire, Hindley and others, are employing horizontal boilers of the locomotive type. Superheat is rarely used, and the working pressure is about 200 lbs. per sq. in. A common type of engine is the vertical or horizontal compound with link motion. In some cases, provision is made for admitting live steam to the low pressure cylinder, when extra or starting power is needed. The cylinder dimensions for a five ton lurry would be about 4 in. bore for the high pressure, and 7 in. for the low pressure cylinder, the stroke being about 7 in., and the normal speed, say 550 revs. per minute. The engine yields about 30 to 35 h.p., and runs some 15 to 20 miles, at full load, on 5 cwt. of coke, and 140 to 200 gallons of water. Transmission is mostly effected by gear wheels and roller chains. The whole machine is simple, strong and economical.

Actual results, obtained by users, show that all costs of running, repairs, depreciation, &c., vary from 2*d.* to 3*d.* per ton mile. Not only does every steam vehicle replace five to ten horses; but, under equal conditions, up to a radius of 20 miles, the ratios of haulage costs by motor wagon and by railway are from 1 to 2 up to 1 to 7, and even higher in favour of the steam wagon. These figures take into account only out loads, so that where return freights are available, the costs are reduced, and

the profits of the lurry proportionately increased.

Yet, in spite of conditions peculiarly favourable to the use of steam, petrol is gaining a hold over heavy goods transport; and several makers who hitherto confined themselves to steam are now also constructing heavy vehicles, tractors and lurries, propelled by petrol, or heavy oil. The road tractor of Messrs. Thornycroft, Ltd. (Fig. 2) might be instanced. The twin cylinder, 25 B.H.P. motor with 6 in. bore, and 8 in. stroke is set vertically beneath the box-shaped portion of the engine body. No radiator is used, but the jacket water on its return to the tank, passes in a thin sheet over a series of inclined wooden diaphragms, enclosed in the cylindrical portion of the engine body. A fly-wheel vane-induced draught is led through this cooling chamber. The exhaust is carried away by the funnel. The drive is through change speed and bevel gear to the countershaft, thence by differential gear and roller-chain. The clutch is of the multiple friction type, running in oil. A slip winding drum permits paying out the hauling cable, while the tractor is travelling or standing; and enables it to haul itself and load up steep inclines or to extricate either or both from bad ground. The driving wheels are 4 ft. 3 in. diameter, with 12 in. tread. To relieve the frame from haulage shocks, the spring is attached to the axle boxes. The axles can rotate independently of the road wheels, or they can be pin-locked, and the differential gear rendered inoperative. The tractor, with fuel for about 110 miles, weighs about three tons, and on hard ground will haul a gross load of 6½ tons up 1 in 8. With spuds, fitted to the wheel, it will extricate itself from soft ground into which it may have sunk nearly to the axle boxes. The Wolseley Company also build petrol tractors, Fig. 3 shows a 2 ft. 9½ in. gauge petrol locomotive recently built for a North of England firm. The horizontal motor is of 20 B.H.P., with twin cylinders of 6 in. bore and 7 in. stroke. The four-coupled wheels are 18 in. diameter. The drive is by a Renold chain, one chain wheel, actuated by friction clutch, is mounted on the crankshaft, and another is fitted

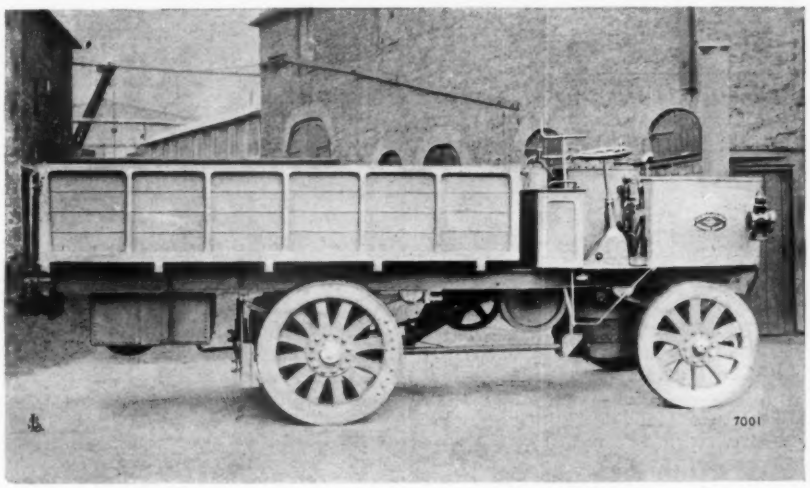


FIG. 5.—HINDLEY LIGHT STEAM DELIVERY VAN. LOAD, 2½ TONS; SPEED, 8—10 MILES PER HOUR.

FIG. 6.—LIGHT COMMERCIAL PETROL VAN, BY MESSRS. DENNIS BROTHERS.

to the first motion shaft in the change speed gear. Two speeds, three and eight miles forward, and two reverse are provided. Radiator, pump, and ballast tank supply the cooling water, and the exhaust is utilised to suck air through the radiator.

(*b.*) *Light Goods Transport.*—With the lighter and speedier vehicles, designed for loads up to one or even two and a half tons, carried at 8 to 10 miles per hour, petrol appears to be driving steam out of the field. It is true that several makers, such as Thornycroft, the Bickford Burners Co., Messrs. Straker and Squire, the Lancashire Steam Motor Co., Hindley, and others, build light steam vans (Figs. 4 and 5); but the tendency in favour of petrol is increasingly strong (Figs. 6 and 7). The transport conditions are less favourable to steam. Light goods deliveries are usually effected with frequent halts, during which economy demands that fuel consumption should cease. This requirement is fully met by the ease with which the petrol motor can be stopped and restarted. The greater fragility of light goods, also, and the higher speeds of conveyance, require spring vehicles. For these the weight of a substantial boiler, engine and fuel bunkers, would be a decided detriment. On the other hand, the reduced gross weight, where they are omitted, allows the use of rubber tyres, and, with these, sufficiently deadened road concussion to admit of the use of petrol mechanism. Weight, in steam vans, can, of course, be saved by the use of oil fuel and flash or semi-flash boilers. But the

FIG. 7.—WOLSELEY 20 B.H.P. PETROL DELIVERY VAN.

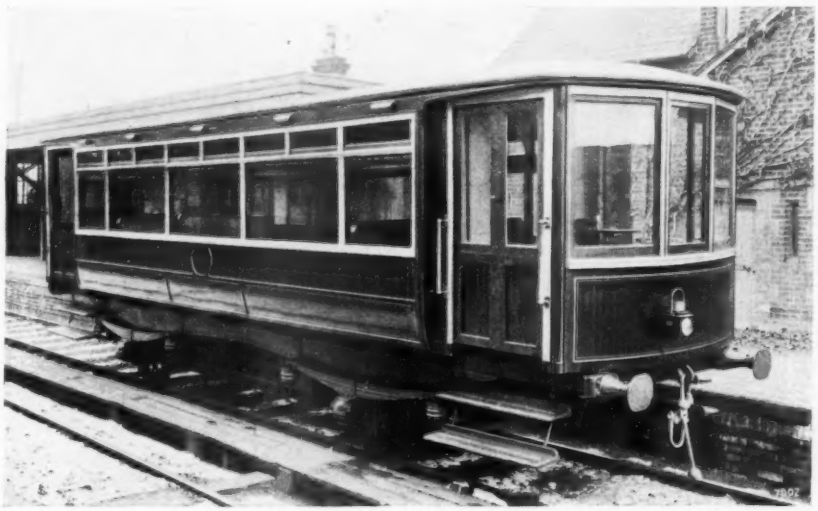


FIG. 8.—RAILWAY PETROL COACH. CHASSIS COMPLETE WITH ENGINE AND GEAR BY THE DAIMLER MOTOR COMPANY.

mechanism is then as complicated as the petrol motor; quite as much, if not more attention is demanded of the driver; and the risks of fire are largely increased. The main requirements of the petrol system for this commercial service are, for economy, a piston speed of 600—750 ft. per minute; ample provision for cooling, as the pace is slow; a forced system of lubrication, in which, as in the Clarkson method, every working part is in turn supplied with a measured quotum of lubricant; protection of working parts from dust, yet their easy accessibility; fool-proof change of speed; auxiliary springs, dash-pot or buffers added to the main springs; lastly, ample strength in all parts.

2. Steam v. Petrol for Passenger Locomotion.

Under this section fall (i.) Public Service Vehicles; (ii.) Pleasure Cars.

(i.) PUBLIC SERVICE VEHICLES.

These comprise (*a*) Road Cars; (*b*) Railway Cars.

(*a*) *Road Cars.*—The service conditions, which, in the transport of light goods, favour the adoption of petrol, tell even more strongly in public service. The strongest argument for steam has been its undoubted reliability; but this argument has now lost its force, since the petrol motor of to-day is as trustworthy as its steam rival. If steam is used, the requirements of space, lightness, and cleanliness almost necessitate the use of oil-fuel and the flash or semi-flash boiler. Nothing has been omitted by manufacturers to improve the burning of oil, to supply the fuel and water in the desired proportions, to regulate the temperature so as to protect the tubes from burning or scaling, &c. But all these improvements have added to the delicacy and complication of the mechanism, so that, in these respects, the modern steam has no superiority over the petrol motor—while it is undoubtedly saddled with, in the writer's opinion, an insuperable bar to extensive use in crowded traffic—namely, the danger of accidental conflagration, which must exist when oil is carried in

proximity to flame and highly-heated metal.

As public service road steam vehicles, the Chelmsford 'buses of Messrs. Clarkson are fine illustrations, and have done excellent work.

(*b*) *Railway Cars.* — Railway companies, with their large equipment of steam rolling stock, their personnel accustomed to steam management, and their shops fitted for steam engine manufacture and repair, may be expected to look somewhat askance at petrol. No doubt there is, in this direction, considerable prejudice. Nevertheless such companies as the Great Eastern, Great Northern, and London, Brighton and South Coast have been induced to test the comparative merits of the two systems. The Wolseley petrol-electric cars, built for the Great Eastern Railway, were perhaps the first to pass satisfactorily through a long series of tests between Filey and Scarborough. The motors on these cars were 90 B.H.P., having four cylinders of 8½ in. bore, and 10 in. stroke. More recently, the well-known Daimler Motor Company of London and Coventry have supplied Messrs. Dick, Kerr and Co. with purely petrol-driven cars (Fig. 8) for use on the Great Northern and the London, Brighton and South Coast Railways. The coach running on the former line is provided with two four-cylinder motors of 4·33 in. bore and 5·90 in. stroke, each engine yielding 36 B.H.P. at 1,000 revolutions per minute. It has done some 4,000—5,000 miles experimental running, and has proved decidedly satisfactory. The coach is electrically lighted, with a seating capacity of 32, and weighs, loaded, under 16 tons. The gear provides for

FIG. 9.—THORNYCROFT PETROL TORPEDO LAUNCH, "DRAGON FLY."

speeds of 8 and 30 miles per hour, at an engine of 800 revolutions per minute; at higher revolutions a speed of over 50 miles per hour has been attained. The operation of changing speeds automatically releases the clutch, and allows it to re-enter, only when the desired speed is engaged. The whole of the machinery is assembled on the frame, beneath the flooring, leaving the full dimensions available for passengers. This increased accommodation, together with instant readiness for use, and non-consumption of fuel between runs, are distinct advantages of petrol over steam for railway work. The London, Brighton and South Coast coaches are equipped with two 30 B.H.P. motors, giving together 100 B.H.P. at 1,000 revolutions per minute. These cars have a 17 ft. 6 in. wheel base, but are otherwise similar to that already described and illustrated.

(ii.) Pleasure Cars.

In the field of sport and pleasure, it can be confidently affirmed that petrol has secured a permanent victory over steam. It is not that the development of the steam vehicle has been neglected. The makers of such cars as the Serpollet, the White, the Turner-Miesse, the Stanley, &c., have every reason to be proud of their work. They have effected vast improvements in generators, in self-starters, in methods of oil and water feed, in the production of the exact steam required for the work, and, in closer approximation in appearance and general arrangement to the workmanlike appearance of the petrol car.

Very creditable, too, has been the achievements of steam cars. The remarkable time of the Stanley car up Mount Washington, beaten only by a 60 h.p. Mercedes; the performance of the Serpollet in the French Gordon-Bennett eliminating trials, by which it won a place as a reserve car; the fastest time, at the Bridgenorth hill-climb, of the Wolverhampton Automobile Club, secured by three Turner-Miesse cars; the first six places, won by White cars at Herefordshire Club hill climb—all testify eloquently to the excellence of design, workmanship, and worth of the modern steam car.

But the manufacturers of petrol cars have also forged ahead. The petrol motor is now scarcely less facile than the electric, or less elastic than the steam engine; possibly less delicate and complicated; certainly less exigent of attention from the driver, quicker to start, economical to use,* and above all, free from the danger of fire.

In the development of the petrol pleasure car, no firm has done so much to retain its premier position in the British trade as the Daimler Motor Co., and in design, material and workmanship their productions outvie anything that can be executed by continental firms.

3. Steam v. Petrol for Special Purposes.

There are purposes for which instant readiness for action is a paramount consideration. The services of the fire-engine on land, and of the life-boat for sea, are instances. In this respect, the petrol motor has superiority over the steam engine, and, in consequence, for both these purposes, petrol is coming to the front. There are other purposes, for which lightness, compactness, safety from fire, and minimum supervision are necessary. Aerial locomotion is a case in point, and here steam cannot compete with petrol.

There are other cases in which a combination of several of the above conditions are demanded by users, for instance, agriculturists. With such, petrol is steadily gaining favour over steam. An 18 B.H.P. motor, complete with all fittings, costing about £300, can be applied to ploughing, reaping, binding, threshing, chaff-cutting, grinding, pumping, &c., or to traction; and for all purposes does its work with rapidity, economy, cleanliness and safety.

* At full load, the average consumption is about ·71 to ·72 pint of petrol per B.H.P. hour.

4. Steam v. Petrol for Marine Work.

For sport, pleasure, submarine boats, and in many cases for naval and commercial launches, petrol is ousting steam. For heavier vessels, the cost of petrol is prohibitive and steam will hold its own, and until such time as it is supplanted by the gas engine and suction generator. Fig. 9 exhibits a striking application of petrol to marine work.

5. Statistics.

A brief but comprehensive view of the relative position of steam and petrol, as applied to self-propelled vehicles, is furnished by statistics,* compiled from eight automobile shows, as set forth in the following table:—

A, Palais, Paris, 20 days in December, 1901.

B, Agricultural Hall, London, 19th to 26th of April, 1902.

C, Crystal Palace, London, 30th January to 7th February, 1903.

D, Agricultural Hall, London, 21st March to 28th March, 1903.

E, Crystal Palace, London, 12th February to 24th February, 1904.

F, Agricultural Hall, London, 19th March to 26th March, 1904.

G, Paris Salon, Grand Palais, 9th to 25th December, 1904.

H, Crystal Palace, London, 27th January to 4th February, 1905.

6. Opinion of Steam Vehicle Manufacturers.

To allay any suspicion of *ex parte* views on the part of the writer, requests were addressed to several steam vehicle manufacturers for the expression of their opinion. The courtesy of the firms supplied the following replies.

Messrs. JOHN J. THORNYCROFT & CO., LTD., CHISWICK.

We think that there is a field for both petrol and steam motors in commercial work, and each would have its separate sphere under different circumstances. For loads of three to five tons, the steam wagon would probably prove more suitable and economical. In general, it is far quieter than would be a petrol or oil engine of similar power, and it is perhaps simpler in construction as well as in working. Assuming that the vehicle is used on long journey work, that is to say from 10 to 20 miles out and the same home, the steam wagon would be more economical to run than would be a petrol vehicle. On the other hand, for light commercial work up to about two tons net load, we are of opinion that the petrol vehicle is more suitable. The necessity of the boiler with the steam engine, while not of so much importance in the case of heavy vehicles, means a considerable proportion of the total weight of the vehicle in the light class, and, in view of the extra speed to be obtained by keeping the gross weight within a certain limit, it is desirable to reduce the weight of the parts of the vehicle as far as possible. The petrol engine undoubtedly scores on this point, and so by its adoption the vehicle carrying such comparatively light loads is enabled to travel faster than would be legal with a steam engine of similar power. Also, the fuel economy of a steam engine and boiler of comparatively small dimensions over the petrol engine is not so great as is the case where larger powers are concerned. Again, very frequently in the case of these light commercial vehicles

THE PERCENTAGE OF POPULARITY—POWER AND DRIVE.

POWER. Percentage of all Motor Vehicles shown (see Gross Totals).	B. Agricultural Hall. 1902.	C. Crystal Palace. 1903.	D. Agricultural Hall. 1903.	E. Crystal Palace. 1904.	F. Agricultural Hall. 1904.	G. Paris. 1904.	H. Crystal Palace. 1905.
Petrol	70·213	82·022	82·618	90·988	90·311	90·995	89·394
Steam	19·757	11·798	11·061	5·719	5·760	1·737	5·303
Electricity	9·726	6·180	6·321	2·946	3·144	7·268	5·303
Petroleum	—	—	—	·347	·785	—	—
Liquid Air	·304	—	—	—	—	—	—
	100·000	100·000	100·000	100·000	100·000	100·000	100·000

Petrol, it will be seen, holds nine-tenths of the propelling power. Steam and electricity run a dead-heat.

* "Crystal Palace Autocar Show Statistics," by H. Hewitt Griffin, *Autocar*, February 11th, 1905, p. 205.

they are required to deliver parts of their load en route, and consequently the vehicle may frequently be standing for some little time. With the steam wagon, the fire in the boiler would have to be kept going all the time whether the vehicle would be kept standing or going, and the consumption of fuel would not greatly vary whether the load were full or light. On the other hand, in the case of the petrol vehicle, the engine would be stopped altogether when the vehicle was at rest and the driver thus freed from attendance on his machine, while the machine itself would not be consuming any fuel.

Another point in favour of petrol vehicles for comparatively light loads is the fact that there is no boiler requiring cleaning out periodically, and, further, the whole vehicle is cleaner, and, therefore, the driver also.

Heavy steam vehicles are generally used for depôt work where full loads are carried for a considerable distance and the vehicle is never kept standing longer than is absolutely necessary. In this case, the simplicity and economy in running steam wagons for such loads far outweighs any advantages which the petrol wagon might have in other respects. We, ourselves, are building at the present time petrol lurries for loads of five tons and over for foreign and colonial use. Also, we have some few steam vans carrying loads of thirty cwt. or thereabouts. The approximate steam consumption with our steam wagons is about 30 lbs. per h.-p hour. We do not use superheated steam in our vehicles.

THE STRAKER STEAM VEHICLE CO., LTD., BUSH LANE, E.C.

We have had fairly wide experience in connection with the employment of Steam *v.* Petrol, particularly for heavy omnibuses, and find the latter to be much preferable to the former.

With regard to carrying freight, our opinion is that anything propelled by petrol engines employed for carrying weights exceeding about two to three tons is undesirable, largely due to the enormous cost of tyre repairs, which renders the vehicle uncommercial as it will not earn sufficient money to make it remunerative. Five-ton oil lurries cannot be fitted with rubber tyres, as the cost is out of all proportion to the advantages gained by the use of the vehicle, and we find when these are employed on steel tyres the light construction will not stand up to the work. Our experience clearly shows that anything from three to five tons must be relegated to steam, unless of course the profits of the car are sufficient to justify the employment of rubber tyres.

THE LANCASHIRE STEAM MOTOR CO., LTD., LEYLAND.

We hold very much to the opinion that petrol machines will be used very extensively for loads up to three or four tons, and for 'bus work, we are certainly going to pin our faith to petrol motors. For heavy work, such as taking five-ton loads, we do not see how petrol can possibly compete with the steam wagon.

We cannot give you the steam consumption in pounds or horse power in our engines, though we can give you the evaporation of our boilers. Taken over four days running, the fuel per gallon of water works out 1·82 lbs., and gallons of water per vehicle mile 6·47 lbs. of coke per vehicle mile 12·00, and the miles per hour 6.

THE YORKSHIRE PATENT STEAM WAGON CO., LEEDS.

We consider steam vehicles for heavy loads preferable to petrol driven, for the following reasons:—1, Initial outlay less; 2, Maintenance, less; 3, Mechanism more easily understood by the average driver; 4, Mechanism not being of such a fragile character is less liable to disarrangement when subjected to rough usage; 5, A little extra power can always be got with a steam driven engine, which is almost impossible with a petrol engine.

With reference to your query, *re* steam consumption, &c., this is a point to which we have not given much attention, and we consider the most vital point to be the fuel consumption. In our vehicles we have found this to be one cwt. of gas coke per 10 or 12 miles (depending upon the size of wagon when travelling with full load.

7. The Future of Steam and Petrol.

Are the position of the two agents to be reversed in the future? We believe not. Any drastic improvement in the steam engine is not to be looked for. On the other hand, the petrol motor—let us rather say, the internal combustion motor—is far from finality. Great improvements are yet in store. Were the writer to prophecy, he would predict, as coming events—the introduction of the two-cycle motor; the supersession of external by internal water cooling, with higher compression; decreased fuel consumption; softer and more elastic action; and, lastly, the displacement of petrol by heavier oils or alcohol. Various efforts have been made to substitute the turbine for the reciprocating motor. The difficulties are very great, and no suggestion that has so far come before the writer in any way solves the problem. Were it solved, would an engine, yielding its power at extremely high rotative speed, requiring great reduction by gearing, be of notable advantage for road transport or locomotion? We doubt it.

The Utilisation of Electric Tramways for the Carriage of Goods.

By ALFRED H. GIBBINGS, M.Inst.E.E., A.M.Inst.C.E.

INTRODUCTION.—Within a period of less than seven years, the development of electric traction in this country may be truly said to have been marvellously rapid. The rate at which Parliament has granted concessions for private enterprise, and the eagerness with which the municipal and local authorities have pressed forward in this matter, has been abnormal in comparison with the progress of any other undertaking of a similar class, not excepting electric lighting.

In 1897, the writer, in conjunction with the city surveyor of Bradford, drew up the first municipal electric tramway specification, and on July 29th, 1898, the working of the first ten miles of municipally-owned electric tramways was successfully inaugurated. Prior to this the only electric lines of any considerable extent were those of the Bristol Tramways and Carriage Co., which commenced running electrically in October, 1895, and the Dublin United Tramways Co., which were opened in May, 1896.

At the present time there are no less than 153 electric tramways and light railways in the United Kingdom, with nearly 2000 route miles in operation. Many of these are in groups, physically connected up and maintaining an interchange of traffic, and hence the possibility arises of conveying goods as well as passengers over these lines. Every Electric Tramway and Light Railway Order contains a schedule of the articles allowed to be carried and the maximum rates and charges for the conveyance of almost all classes of goods, animals, and things which include such heavy pieces as boilers, stone, machinery, &c., of which any single piece may weigh over eight tons. In fact, such facilities are granted for the carriage of goods, on electric tramway systems that it is impossible to forecast the extent of the probable development in this direction in the immediate future.

It will be apparent therefore, that the very short time which has elapsed since the introduction of electric traction, has precluded any very striking progress on the "goods" side of these undertakings; indeed, in some cases, it has not been possible to meet adequately the demand of "passengers." On the other hand, however, it has been found that on many of the inter-urban and rural tramways, the traffic receipts from passengers have not been, and are not likely to be, sufficient to meet expenditure owing to the high initial cost of construction. The problem of goods traffic is thus, at the outset, confronted with two difficulties of an entirely opposite character. On the one hand the town systems are already overcrowded with cars and are earning enormous profits; on the other hand the urban and rural systems are handicapped by unrenumerative capital and are limited in their scope and extent. It is true that this is only one aspect of the subject, but typical of many other difficulties which present themselves, and are the first and most important requiring solution, and it is clear that some compromise must ultimately be arrived at.

There will be no need to enumerate those towns which are fortunately situated in having good dividend-earning undertakings, but some instances of the opposite class may be cited here in order to indicate clearly the necessity which exists for them to use all their available powers in order to increase

their earning capacity. The following tabulation shows the loss sustained in operation on a passenger traffic basis.

TABLE SHOWING LOSS ON ELECTRIC TRAMWAY UNDERTAKINGS.

Name.	Commencement of Electric Running.	Length of line open. Miles.	Deficit for 1904.
Aberdeen ...	1899	25	No profit.
Birkenhead ...	1901	23	No profit.
Blackburn ...	1899	24	£5,138.
Brighton ...	1901	13	£4,779.
Burnley... ...	1901	19	No profit.
Burton-on-Trent	1903	8	No profit.
Darwen... ...	1900	6	£1,485.
Farnworth ...	1902	7	£1,780.
Halifax	1898	44	No profit.
Huddersfield ...	1901	35	£4,911.
Ipswich... ...	1903	12	£1,920.
Lancaster ...	1903	3	£2,833.
Leicester ...	Horse trams	16	£1,330.
Lowestoft ...	1903	6	£226.
Northampton ...	Horse trams	9	£392.
Oldham... ...	1902	28	£7,826.
Reading ...	1903	13	£543.
Rochdale ...	1902	5	£4,037.
Rotherham ...	1903	9	£17.
Southport ...	1900	19	£341.
Warrington ...	1902	9	£783.
Wolverhampton	1902	13	£2,366.
Great Yarmouth	1902	5	£215.

The position in which these undertakings find themselves is indeed unfortunate. Before commencement of operation it was almost impossible to tell with any degree of accuracy what the number of passengers per car mile would be, and hence the nature of these promotions has been highly speculative. When once this figure has been ascertained it is in most cases almost invariable from year to year and so, unlike most other business ventures, the tramway is absolutely circumscribed in its development. So far, however, we have been referring to passenger traffic alone. There remains yet one solitary hope to admit of these concerns being placed on a sound financial footing. That hope is in the carriage of goods.

Progress.—Let us make a brief survey of what has already been done.

Attention was first called to the potentialities of a goods traffic on electric tramway systems by passing the Light Railways Act, in 1896, which to all intents and purposes has in almost every instance been used to obtain electric tramway powers instead of applying under the Tramways Act, 1870. The Light Railways Act was passed with the special object of facilitating the transport of goods, but more particularly agricultural produce, from country districts to railway centres, canals, towns, &c. It has not yet fulfilled the object of its existence, but indirectly, through the construction of a large number of inter-urban tramways and light railways, it may ultimately do so.

In 1900—1901, the writer was interested in the development of the South Lancashire Tramways, which serve an area full of promise for the most successful growth of goods traffic, a careful canvass showing an enormous amount of road conveyance of a wide variety of goods. This was fully described in an article entitled "The Conveyance of Goods on Electric Trolley Lines."* Papers by the writer were also read on the subject before the British Association in September, 1901, and the Liverpool Engineering Society in January, 1902. The compilation of these papers necessitated enquiry into all sorts of conditions, pro and con, which exist in this country; into many similar cases on the continent and in the U. S. A., where more progress has been made, and the discussions which arose at the reading of the papers brought out many novel and striking features. Several of these will be referred to further on in this article.

The next step, it is a pleasure to record, has been a practical application of the powers which hitherto have lain dormant. It consists in the inauguration of a local parcels service on several systems, on some of which it has been very completely and extensively organised.

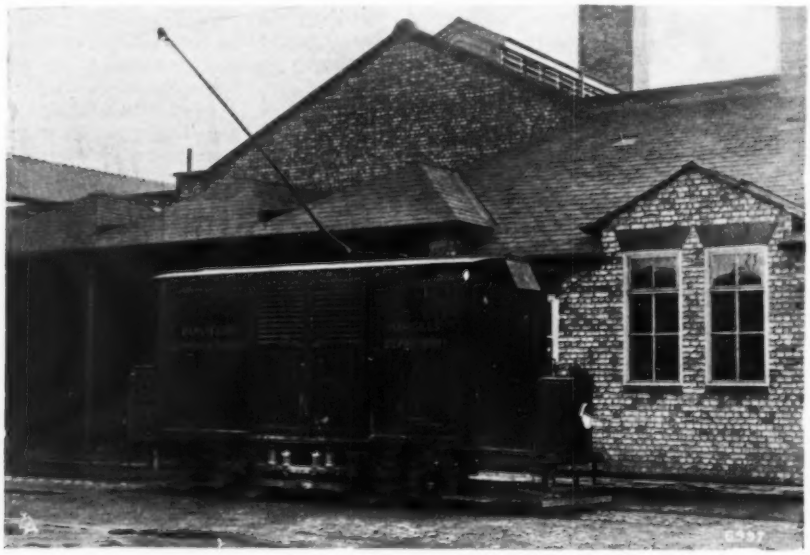
The undertakings which have made this attempt are:—Manchester Corporation, Bradford Corporation, Dublin United Tramways Co., Ltd., Dundee

* *Traction and Transmission* in April and May, 1901.

Corporation, Edinburgh and District Tramways Co., Ltd., Huddersfield Corporation, Bury Corporation, Gravesend and Northfleet Electric Tramways, Ltd., Ipswich Corporation, Reading Corporation, Potteries Electric Traction Co., Halifax Corporation and the London United Tramways Co.

A full description of most of these schemes has appeared in the technical press, but it is not the intention here to describe or enlarge upon the details of a parcels service. It will suffice to remark that the Manchester Corporation has designed the special goods or parcels van, which runs between the passenger car services throughout the day, and is here shown in our illustration. This van is almost identical with the type which has been used for many years by the Pittsburgh Express Company, Pittsburgh, Pa. It is a clear indication that the business will not be allowed to rest within the limits of parcel conveyance, but that when some of the more obstructive difficulties have been overcome, the carriage of goods will commence in earnest.

The incentive thus given to a new departure, the creation of a new department, distinct and separate from passenger traffic will doubtless rapidly spread to other undertakings, until its familiarity and association with the existing services will remove a very considerable objection to the utilisation of electric tramways for the carriage of goods.



PARCELS VAN, MANCHESTER CORPORATION ELECTRIC TRAMWAYS.

Beyond the movement in connection with parcels, very little has yet been done towards inaugurating a comprehensive goods service. The Huddersfield Tramway Department are carrying coals over their lines, and in 1901, the South Lancashire Tramways Co., appointed a goods traffic manager, but gave up the idea through want of capital.

At the annual meeting of the Potteries Electric Traction Co., on April 11th

this year, the chairman, Mr. G. F. M. Cornwallis-West, said :—

> "There had been an increase again in the parcels traffic, the number of parcels carried being 209,633, and the receipts had increased correspondingly. Other tramway undertakings, both municipal and otherwise, had taken up this important subject, and the Potteries Company had been the model in many instances upon which these systems had worked. It was to be hoped that in the near future it would be possible for these concerns to form some sort of combination whereby they could act as each other's agents in the districts they served, and so enormously increase the volume of business, and thus reap the profits now obtained by intermediaries. The carriage of heavier goods was receiving the directors' attention, and application had been made to the local authorities with reference to the construction of sidings to facilitate such traffic, but so far unsuccessfully."

This undertaking is one of the large group of tramways associated with the British Electric Traction Co., and it may be assumed therefore that the foregoing speech indicates that the British Electric Traction Co., attach considerable importance to the goods traffic problem.

Difficulties.—In enumerating the difficulties of inaugurating a goods service on electric tramways, no regard need be given to such objections as may be classed as æsthetic, constructive, or purely traffic troubles. These are simple and weigh but little in comparison with those of a more obstructive and real nature. Indeed, there are some which must be removed, notwithstanding the facilities and powers already conferred by the Acts and Orders, before any business can be done.

In the first place even the carriage of parcels has met with strong local opposition in Manchester, and has involved the corporation of Manchester in serious litigation on a question, the decision of which will be awaited with great interest.

When the scheme was mooted, it met with determined opposition from the private traders whose businesses it seemed likely to affect. A well-known parcel carrying firm of Manchester, has now served a writ on the corporation in which they set forth the following claims :—

(1) A declaration that the defendants have no power to convey, collect, or deliver by means of road vans, handcarts, or messengers; to act as general carriers or delivery agents, general forwarding or railway agents; or to undertake the collection of the value of goods on delivery.
(2) An injunction restraining the defendants from acting as above.
(3) A declaration that it is unlawful to spend money out of the city funds or the tramways receipts for any such purposes.
(4) An injunction restraining such spending.
(5) A declaration that it is unlawful to use the buildings, plant, and servants of the tramways undertaking otherwise than for strictly tramway business.
(6) An injunction restraining the defendants from such use.

The writ has been granted in the Chancery Division of the High Court, and the Tramways Committee gave the Town Clerk authority to defend the action.

Without attempting in any way to pre-judge the merits of this action, there can be no question but that it amounts to an admission that the tramway parcels service is a better and more expeditious service than the horse and van service, and hence becomes a serious competitor. We have long since passed the day when Parliament plumped for the monopolist against the public interest, as the railway companies have found out to their chagrin in connection with tramway legislation.

The other drawbacks may be summarised as follows :—

(1) Co-operation with regard to interchange of traffic and through running powers by contiguous undertakings.
(2) Sidings from main lines and into private premises.
(3) Collection and delivery to and from places remote from the service lines.
(4) Trailers and marshalling.

Circumscribed space prevents these difficulties being dealt with here in any other than a cursory manner. With regard to the first, running powers necessarily implies two things. In the first place it is an arrangement by which the goods can be carried from point to point.

Secondly, it is obviously necessary that the rail gauges must be the same throughout, and that the method of haulage or traction should be identical. In other words, the systems must be the same in both cases. In the majority of systems of electric traction in this country the conditions are almost identical, with the exception in a few instances of gauges narrower than 4 ft. 8½ ins. The difficulty therefore resolves itself into the possibility of agreement or co-operation between two or more contiguous authorities. This is a portentous subject in itself, especially when one considers the usual type of ratepayer who figures conspicuously in all negotiations, whether the undertaking is owned by the local authority or by a company. Some attempt, however, has been made by a committee in Lancashire consisting of representatives from the Liverpool Corporation, other corporations, Liverpool Chamber of Commerce, Mersey Dock and Harbour Board, and mill owners &c., to arrive at some common basis for the conveyance of goods over all the South Lancashire systems, including Manchester and the district east of it, bordering on Yorkshire. No report of the proceedings has yet been issued.

The next difficulty relates to the question of sidings into mills, collieries, railway yards and similar places.

A very real and immediate difficulty arises in obtaining the sanction to lay additional lines and sidings. It has been referred to in the speech of Mr. G. Cornwallis-West, quoted herein. It affects both municipal and private enterprise alike, although of course the private enterprise is in much the worse position, because it would frequently have to obtain the sanction of the local authority as a *sine qua non*. Under the existing legislation, therefore, it is possible for a local authority or private individual (as a frontager for instance) to withhold in the most arbitrary manner the consent which is necessary, to lay even a special siding into premises. Therefore, whether powers have been obtained under the Tramways Act, or Light Railways Act, the whole course of the original procedure of applying for powers has to be repeated for every additional line or siding required. It is at once apparent that such a condition becomes practically prohibitive in consequence of the costs and delays involved.

It is true that the Board of Trade can exercise very limited powers in this respect, but after a concession has been obtained in the usual way, it should not be allowed to remain practically impossible to obtain such reasonable and beneficial extensions, as special short lines to mills, and sidings from the predetermined track. This appears to the writer to be the most important obstacle to be removed, for it would also supply the key to many of the other difficulties. The difficulty might very well be dealt with on a similar basis to the laying of service lines from electric light street mains, provision for which (including extensions of mains) is made in the Electric Lighting Acts, 1882 and 1889.

The collection and delivery of goods to and from places remote from service lines or depôts is a problem which can only be solved very gradually and in accord with the exigencies of the business to be done. Given the facility to lay additional sidings, and short extensions into mills, collieries, &c., much supplementary collection &c. would be avoided. It must not be forgotten that the essence of economy in connection with the carriage of goods on electric tramways is the avoidance of loading and unloading several times in the course of one journey. Hence, whether the collection of goods is from points near to or remote from the system, some method of handling and transferring in bulk must be adopted. With the horse-drawn lurry this has been a difficult, if not an impossible matter, but with the new motor lurries the transference and carriage is simplified The platforms and upper portion of trucks and lurries should be identical, interchangeable, and readily removable from one to the other when fully loaded.

The employment of trailing cars is also not yet permitted by the Board of Trade. It is not anticipated that more

than two or three trailers would ever be required, except perhaps in a purely local service in country districts. The employment of trailers involves shunting and marshalling, both objectionable and uneconomical methods, but nevertheless it would very often be a great convenience and great economy to make use of one or two trailers. So far, however, this is not premitted on lines in this country, but it is a common feature in the U. S. A. and on the Continent.

Advantages.—The advantages which would accrue from the utilisation of electric tramways for the carriage of goods would be, broadly speaking, two-fold. In the first place an increased revenue and reduced standing charges would result to the undertaking; and secondly a healthy competition would be set up between this departure and existing carriers, including the railway companies. Thus the local manufacturer, colliery owner, agriculturist, and tradesman would benefit by cheaper rates of transit for their goods and an incentive would at once be given to the improvement of local conditions and trade generally. When once the main obstacles to the initial start are removed, or at least considerably modified, and assuming the same rapid development as was experienced with electric tramways, it is safe to predict that this new boon will soon become a formidable competitor with railway companies, and therefore of national importance. High railway rates has long been a subject of strong complaint by all importers and exporters, both with regard to raw produce and the manufactured article, and until some form of competition, in the nature of cheaper rates and fairly rapid transit is introduced, no hope of a reduction is tenable.

There is, therefore, the very strongest reason why all local industries and ratepayers should assist in every possible way towards the inauguration of this most desirable facility.

The question that immediately arises is, how is it possible for tramways to offer cheaper rates of carriage than railways? If we take the capital cost of a tramway undertaking, we find that it is proportioned somewhat as follows:—

	Per cent.
Permanent Way, Overhead Equipment, &c.	60
Generating Station, Car Sheds, &c. ...	25
Rolling Stock	15
	100

From this it will be seen that the utilisation of the permanent way would result in reduced standing charges to both passenger and goods departments to the extent of a large proportion of capital. Maintenance charges would still remain the same for both concerns, though in reality doubled due to extra wear and tear. The greatest economy, however, would arise from the through conveyance of goods, not necessarily on the same vehicle, but without re-handling in detail. Hence such charges as warehousing, service terminal charges (often the most serious and heavy charge of all), loading and unloading, and shunting costs, would be greatly reduced, if not totally avoided in the majority of cases. Incidentally such an arrangement should be also to the benefit of the railway. With properly constructed interchangeable truck bodies, goods could be transhipped in bulk to the railway, and thus the long distance goods traffic would be augmented and made more profitable.

Other indirect advantages are also possible. The increased traffic on the system will tend towards the reduction of the cost of electrical energy, by increasing the load-factor of the generating station. The difference may be represented as the saving between a 60 per cent. and a 40 per cent. load-factor, or in other words more than 20 per cent. more energy can be generated at the higher load-factor at the same cost. Another detail in economy is the saving in road repairs and maintenance to the local authority through lessened horse and lurry traffic, and that this is likely to be of real importance, appears from papers read by eminent engineers and road surveyors.

Transport in Relation to Agricultural Co-operation.

By F. F. BENNETT, M.I.E.E.

By the advent of the motor steam wagon the means are to hand for the establishment of an ideal system of transport and co-operative trading in agriculture.

By an ideal system, I mean a comprehensive scheme by which producers could deal direct with consumers, and the transport of produce being possible of establishment without resort to the services of railway companies.

Formerly I was rather sceptical as to the value and efficacy of steam wagons in matters of heavy goods haulage. My impression leaned towards the possibility of delays, heavy depreciation and repairs, failure of human endurance by the wagon driver, breakdowns and general interference in the continuity of service, compared with that obtaining on the railway system.

During the last few weeks, I have, under my own supervision, conducted some severe trials with a steam wagon, with the result that I am now perfectly convinced that the before-mentioned difficulties exist only in a small degree, and by proper organisation and intelligent and conscientious superintendence, a motor wagon service could be exploited in as regular and reliable a manner as that of the present railway medium, with the advantage of greater economy.

The trials referred to consisted of the daily running of a Yorkshire steam wagon on a round of fifty-four miles. On the wagon was conveyed a load of four tons, and a trailer was hauled upon which was deposited a further three tons, making seven tons of goods in all.

Owing to the extremely hilly nature of the district, I consider that the trials indicated were the most severe of any yet successfully undertaken by this type of vehicle.

The route followed was :—

Manchester to Burnley, *via* Oldham, Rochdale and Bacup; returning to Manchester *via* Rawtenstall, Ramsbottom and Bury.

The time occupied in actual travelling was eleven hours, a mean of five miles per hour.

In the first eight miles, Manchester to Oldham, the climb was 300 feet, mean rise 1 in 32, maximum rise, half a mile of 1 in 12.

Oldham to Gravel Hole, three miles, rise 355 feet, mean rise 1 in 45.

Gravel Hole to Broad Clough, eight miles, rise 350 feet, mean rise 1 in 118.

Broad Clough to Heald Moor, two miles, rise 458 feet, mean rise 1 in 23. Heald Moor is 1,350 feet above sea level.

Leaving Burnley on the return journey there is for two miles a big climb to negotiate, equal to 1 in 21.

On some portions of the route, and for short distances, I estimate the maximum gradients overcome to be quite 1 in 10.

The fuel used was coke at 8*s*. per ton, the consumption being 1,134 lbs. for the whole journey, equivalent to 21 lbs. per wagon-mile, and 3 lbs. per nett ton-mile.

On a fairly level road, the latter item could be considerably reduced, probably on South of England roads it would not exceed 18 lbs. per wagon-mile. Experience subsequently gained of tests in fuel consumption in other directions, has proved this theory to be correct.

The total time taken to cover the distance, including all stoppages for

handling of goods, watering up, &c., was sixteen hours.

The locomotion per nett ton-mile, and per ton carried per week was ascertained to be as follows :—

5 days × 7 tons = 35 tons carried each way = 70 tons × 27 miles = 1890 ton-miles.

CAPITAL COST OF PLANT USED.

	£
Wagon	500
Trailer	50
Oil sheets, linen sheets, ropes, etc.	50
	£600

COST OF RUNNING

	£	s.	d.
Fuel (coke)— 54 × 21 × 5 = 5,670 lbs. = 2½ tons at 8s.	1	0	0
Oil, waste and water ...	0	5	0
Drivers' wages, 80 hours at 7d.	2	6	8
Assistants' wages, 80 hours at 4d.	1	6	8
15 per cent. Repairs on £600	1	15	0
10 per cent. Depreciation on £600	1	3	4
5 per cent. interest on capital	0	11	8
Total per week	£8	8	4

Cost per ton carried.

$$\frac{£8\ 8s.\ 4d.}{70} = 2s.\ 5d.$$

Cost per ton-mile.

$$\frac{£8\ 8s.\ 4d.}{1{,}890} = 1{\cdot}07d.$$

The satisfactory results emanating from the action of this wagon, with maximum load and over such a mountainous route, convinced me conclusively that its adaptability for useful and economic work on easier roads was beyond question, and coupled with intelligent and experienced supervision, would prove a priceless boon in the agricultural world. Especially in view of the fact that the average roads to be traversed would be comparatively level.

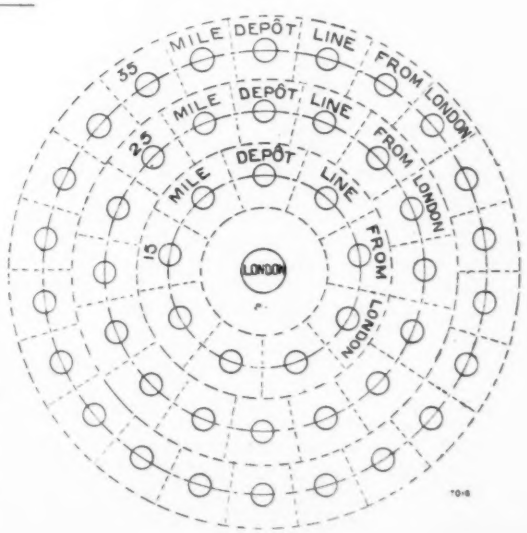
With this certain knowledge in our possession, the next point to consider, is, in what way can steam wagons be adapted to agricultural pursuits?

My own idea is, to first choose a convenient and suitable centre for operations, and naturally my choice falls upon the London district. There is no doubt in my mind that such a scheme properly managed would lead to highly remunerative results.

All towns of large population would, however, be applicable, and the system successful; but London with its dense population, surrounded by purely agricultural country, renders it pre-eminently suitable for my purpose.

By reference to the plan it will be seen that a circular line is drawn at a 15 mile radius from the centre of London; a second line is drawn at a 25 mile radius, and a third line is drawn at a 35 mile radius.

Along the first line I would establish a collecting and distributing depôt – one every ten miles—making nine depôts.



Along the second line I would establish one depôt, also at every ten miles, making sixteen depôts.

Along the third line, depôts the same distance apart, making twenty-two depôts.

Thus the total number of depôts would be forty-seven.

Each depôt to serve a radius of five miles, this covering an area of practically 100 square miles.

The farmers and traders domiciled in such area could convey their outwards goods and produce by cart to the depôt, and return with any inwards material consigned to them.

The depôts need not be costly structures, but should be of sufficient size to accommodate three steam wagons with trailers, on one side of a platform, with space for half a dozen carts on the other side.

I estimate the cost per depôt with land, to not exceed £1,000.

In the 100 square miles of which a depôt is the centre, I assume there are 105 farmers, tradesmen, and others, who would be likely to participate in the scheme.

I estimate that each of these would use the system at a mean rate of one ton each way, inwards and outwards per week.

Thus calculations for dealing with 105 tons each way per week should be made.

Three motor-wagons and three trailers would suffice for each depôt, and for clearing twenty-one tons each way per day for five days per week.

I would further suggest a spare wagon with trailer for every three depôts, to be kept in readiness for immediate dispatch against a breakdown. The proportion would thus be at the rate of $3\frac{1}{3}$ motor-wagons to each depôt.

At the markets in London, it would be essential for the association to have its own premises and staff.

For this I allocate in the estimates the sum of £208 per annum per depôt.

Supplementing the Lancashire figures of 1·07*d.* per ton-mile, with the cost of running this service, we have the following results :—

CAPITAL EXPENDITURE.

	£
$3\frac{1}{3}$ Steam-wagons, trailers and equipment	2000
Depôt building and equipment	1000
Total	£3000

Cost per week for carrying 105 tons each way, between London and the depôt on No. 1 line, fifteen miles each way, and allowing three hours for delays in handling of goods, or nine hours for the return trip.

ESTIMATE No. 1.

	£	s.	d.
Fuel (coke)—			
90 × 18 × 5 = 3 tons, 12 cwt. at 10*s.*	1	16	0
Oil, waste and water ...	0	12	0
Drivers' wages—			
45 × $3\frac{1}{3}$ × 7*d.*	4	7	6
Assistants' wages—			
45 × $3\frac{1}{3}$ × 4*d.*	2	10	0
Repairs, 15 per cent. on £2,000	5	15	0
Depreciation, 10 per cent. on £2,000	3	17	0
Repairs, 5 per cent. on £1,000	0	19	3
Depreciation, $2\frac{1}{2}$ per cent. on £1,000	0	9	7
Interest, 5 per cent. on £3,000	2	17	9
Depôt staff (foreman, clerk and odd man)	4	0	0
London Market expenses ...	4	0	0
Insurance, rates and sundries	3	10	0
Total weekly expenditure	£34	14	1

105 tons each way = 210 tons carried.

$$\frac{£34\ 14s.\ 1d.}{210} = 3s.\ 4d.\ \text{per ton carried.}$$

$$\frac{£34\ 14s.\ 1d.}{210 \times 15} = 2{\cdot}64d.\ \text{per ton-mile.}$$

ESTIMATE No. 2.

(Depôt No. 2, circular line 25 miles from London).

	£	s.	d.
Fuel (coke)—			
150 × 18 × 5 = 5 tons, 12 cwt. at 10*s.*	2	16	0
Oil, waste and water ...	0	12	0
Drivers' wages, 63 × 3½ × 7*d.*	6	2	6
Assistants' wages, 63 × 3½ × 4*d.*	3	10	0
Other items the same as on Estimate No. 1	25	8	7
Total weekly expenditure	£38	9	1

$$\frac{£38\ 9s.\ 1d.}{210} = 3s.\ 8d.\ \text{per ton carried.}$$

$$\frac{£38\ 9s.\ 1d.}{210 \times 25} = 1{\cdot}75d.\ \text{per ton-mile.}$$

ESTIMATE No. 3.

(Depôt on circular line, No. 3, 35 miles from London).

	£	s.	d.
Fuel (coke)—			
210 × 18 × 5 = 8 tons, 9 cwt. at 10*s.*	4	5	0
Oil, waste and water ...	0	15	0
Drivers' wages—			
85 × 3½ × 7*d.*	8	5	3
Assistants' wages—			
85 × 3½ × 4*d.*	4	14	5
Other items the same as on Estimate No. 1	25	8	7
Total weekly expenditure	£43	8	3

$$\frac{£43\ 8s.\ 3d.}{210} = 4s.\ 1d.\ \text{per ton carried.}$$

$$\frac{£43\ 8s.\ 3d.}{210 \times 35} = 1{\cdot}4d.\ \text{per ton-mile.}$$

In all the three depôts, the mean cost per ton carried would be 3*s.* 8*d.*

The mean cost per ton-mile = 1·93*d.*

This total cost would include the depôt expenses and charges, and an outside figure of £4 per week per depôt for rent, rates and staff expenses in the London markets. A much less expenditure than this would probably obtain as the number of centres increased and became operative.

For purposes of comparison with present railway rates it would be necessary to deduct from the foregoing estimates the amounts debited to the London market expenses, viz., £4 per week per depôt.

Cost per ton carried and per ton-mile on the 15 mile radius 2*s.* 11*d.* per ton carried and 2·34*d.* per ton-mile.

Cost per ton carried and per ton-mile on the 25 mile radius, 3*s.* 3*d.* per ton carried, and 1·57*d.* per ton-mile.

Cost per ton carried and per ton-mile on the 35 mile radius, 3*s.* 9*d.* per ton carried, and 1·29*d.* per ton-mile.

Mean cost per ton carried = 3*s.* 4*d.*, and mean cost per ton-mile 1.73*d.*

On the full development of the scheme the results would come out considerably better, as the outer 35 mile radius line would tap or serve the greater number of farmers, and therefore, the greater number of depôts would be required.

I estimate the total possibilities of the scheme to be on the first line (15 mile radius) 9 depôts having 945 tons each way per week.

On the second line (25 mile radius) 16 depôts having 1,680 tons each way per week.

On the third line (35 mile radius) 22 depôts, having 2,310 tons each way per week.

Making a grand total of 4,935 tons each way per week, equal to 9,870 tons in all.

I allocate the costs as follows:—

1,890 tons (15 mile radius = 28,350 ton-miles at 2·34*d.*; 3,360 tons (25 mile radius) = 84,000 ton-miles at 1·57*d.*; 4,620 tons (35 mile radius) = 161,700 ton-miles at 1·29*d.*

	£	s.	d.
To work depôts and locomotion, No. 1 Line	276	6	9
Ditto, No. 2 Line	551	5	4
Ditto, No. 3 Line	867	1	6
	1694	13	7
London Market expenses, 47 depôts at £4	188	0	0
Total expenditure per week	£1,882	13	7

The mean cost per ton carried, and per ton-mile when the complete scheme is in operation would be :—

$$\frac{£1,694\ 13s.\ 7d.}{9,870\ \text{tons}} = 3s.\ 5d.\ \text{per ton carried.}$$

$$\frac{£1,694\ 13s.\ 7d.}{274,050\ \text{ton-miles}} = 1{\cdot}48d.\ \text{per ton-mile.}$$

The fact must not be overlooked that all these charges contain 15 per cent. for repairs, 10 per cent. for depreciation, and 5 per cent. interest on capital, except the depôt buildings which are charged with 5 per cent. repairs and 2½ per cent. depreciation only, plus 5 per cent. interest on capital.

The total capital required to carry out the complete scheme would be :—

47 depôts at £3,000 = £141,000.

In each of the 100 square miles, of which a depôt forms the centre, there should be at least one farmer, tradesman or other person, to whom a scheme of this nature would be of incalculable value; it would, therefore, behove such an individual to contribute a proportionate share of raising the necessary capital, viz., £3,000, in order to have the idea formulated in his district.

Were 100 (one to each square mile) such interested parties to each subscribe £20, the sum of £2,000 could be raised. With this start it would then be no difficult matter to raise the balance from outside, by means of debentures bearing 5 per cent. interest.

For the whole scheme, in its entirety, 4,700 subscribers or shareholders would be essential.

	£
4,700 shares at £20	94,000
2,350 5 per cent. debentures at £20 ...	47,000
Total capital required ...	£141,000

The area proposed to be served is 4,700 square miles, one £20 shareholder in each square mile would be sufficient to launch the complete scheme.

As others besides shareholders would be willing to use the system, it would only be fair to make this class of customer pay an additional rate to that required from a subscriber, in fact the latter should enjoy a preferential rate of at least 20 per cent.

The following rates levied would make the scheme remunerative:—

		Per ton. s.	d.
To subscribers on the	No. 1 Line ...	3	0
Ditto	No. 2 Line ...	3	6
Ditto	No. 3 Line ..	4	0
To non-subscribers	No. 1 Line ...	4	0
Ditto	No. 2 Line ...	4	6
Ditto	No. 3 Line ...	5	0

The sum of £9,776 per annum (on the whole scheme) is set aside in the estimates for dealing with and handling the goods and produce, both inwards and outwards, in London.

In addition to this I consider that this figure possesses sufficient margin to overcome the expense necessary to obtain direct dealings with wholesale and retail dealers, and to cover the rents of premises in each of the London Markets, to pay sufficient and competent salesmen, in order to dispose of produce at the current rates and prices obtaining; and to cover the overseering in connection with return loads, or traffic.

A considerable profit should result from the application of the rates suggested. Assuming that the total traffic were divided up equally (inwards and outwards) between the subscribers and non-subscribers, the gross revenue for the 47 depôts in operation, per week, would be :—

	£	s.	d.
No. 1 Line, 9 Depôts, 945 tons at 3s.	141	15	0
Ditto 945 tons at 4s.	189	0	0
No. 2 Line, 16 Depôts, 1,680 tons at 3s. 6d.	294	0	0
Ditto, 1,680 tons at 4s. 6d. ...	378	0	0
No. 3 Line, 22 Depôts, 2,310 tons at 4s.	462	0	0
Ditto, 2,310 tons at 5s. per ton	577	0	0
Gross weekly revenue ...	£2,041	15	0

Equal to a gross annual revenue of £106,171.

The annual cost of working would be :—

£1,882 13s. 7d. × 52 = £97,899

Leaving a nett revenue or profit of £8,272.

Thus a profit of 9 per cent. on the subscribers' capital, in addition to the 5 per cent. interest allowed for in the estimates, would accrue annually, equal to 14 per cent. and £12,972.

This is equivalent to a return or rebate of practically one third of the total sum paid by subscribers for their freights, and for comparative purposes would mean a reduction of rates to 2*s.*, 2*s.* 4*d.*, and 2*s.* 8*d.* respectively of the line of depôts concerned.

Although the running of the advocated system would obtain freights at infinitely less than those prevalent at the present time on the railways, these benefits would sink into insignificance compared to the advantages which would accrue from the establishment of the co-operative portion of the scheme.

By bringing the produce and wares into direct touch and dealings with the retailer and consumer, the producer would receive better prices, as the middle man would disappear and his profits with him.

It is difficult to estimate what these additions to profits would be, but in course of conversation with an eminent agricultural authority, the writer elicited the opinion that at least 20 per cent. better prices would accrue to the farmer.

Another most important factor is the obtaining direct, and in large quantities, the inwards merchandise.

Under the scheme the proposed Co-operative Association would embrace 4,700 members, with the probable additional patronage of 4,700 non-members.

These together would represent 9,400 families, each requiring about five tons of coal per annum, a total of 47,000 tons.

The management of the Association could make annual contracts for coal, manure, provisions, and other commodities. This would necessitate orders being placed for very considerable quantities at best London wholesale prices, so that subscribers would enjoy to the fullest extent, the lowness of cost for all imported articles of home consumption.

With regard to coal, contracts could be placed direct with the Northern seaboard collieries, ships chartered to bring it to a London dock or wharf, from whence it could be conveyed and distributed amongst the numerous depôts by the steam wagons.

In these circumstances, the first cost would be pit-brow prices, plus steamship transport, dock dues and cost of haulage.

Non-members should be compelled to pay at least 10 per cent. more than members, if they wish to participate in all these advantages, so that the profits would still swell up in a very satisfactory way.

My prognostications are based upon the total inwards and outwards traffic being equal, or in like proportions; should I be in error in this supposition, and the inwards traffic is not of the same ratio as the outwards, then a small recasting of rates to meet any difference would be essential; but I do not anticipate any great alteration in this respect.

I would advocate a modest commencement; were a start made with three depôts, one on each radius line, sufficient experience would emanate from the experiments and serve to illustrate the success of the venture.

After three months of such working, and when my figures are correctly borne out by results, increased depôts could be erected and additional steam wagons brought into requisition.

Similar systems might gradually be adopted in the districts claiming Manchester, Liverpool, Birmingham, Leeds, Sheffield and Bradford, as their respective centres; but in a more modest degree, as the demands for agricultural produce obtaining in those centres, would not in any way approach the magnitude of that of London.

The preferences and favour shown to foreign traders by our English railway system, compared to that shown to British merchants, is both iniquitous and unfair.

The rate paid per ton-mile, by the

foreigner, for through goods on British railways, is less than one half of that exacted from his English competitor.

To show how British internal trade is handicapped by heavy railway rates, the following list will demonstrate the advantages possessed by the foreign producer over his brother in this Country :—

Carriage of a ton of apples, Folkestone to London, £1 4*s*. 1*d*.

Carriage of a ton of apples, California to London, 15*s*. 8*d*.

Carriage of a ton of British meat, Liverpool to London, £2.

Carriage of a ton of foreign meat, Liverpool to London, £1 5*s*.

Carriage of a ton of eggs, Galway to London, £4 14*s*.

Carriage of a ton of eggs, Denmark to London, £1 4*s*.

Carriage of a ton of eggs, Russia to London, £1 2*s*.

Carriage of a ton of eggs, Normandy to London, 16*s*. 8*d*.

Carriage of a ton of plums, apples, and pears, Queensborough (Kent) to London, £1 5*s*.

Carriage of a ton of the same from Flushing (Holland), 12*s*. 6*d*.

Carriage, per ton, of English pianos, Liverpool to London, £3 10*s*.

Carriage of above, of foreign, £1 5*s*.

British timber, per ton, Cardiff to Birmingham, 16*s*. 8*d*.

Foreign, as above, 8*s*. 10*d*.

Carriage of nails, wires, tubes per ton, from Birmingham to London, 10*s*. 9*d*.

Carriage of same, from Germany, 4*s*. 9*d*.

Carriage of English spades, per ton, £1 1*s*. 9*d*., of German, 6*s*. 6*d*.

In the carriage of iron ore and steel rails, the American railway charge 6*s* 3*d*., where the British charge 9*s*. 3*d*.

The foreigner enjoys not only low rates for railway freights in this country; but he possesses a distinct advantage by corresponding low rates in his own country.

The average cost per ton-mile in Germany is only ½*d*.

For every 1,000 tons of traffic carried a mean distance of twenty-five miles, the British trader pays about £100 over and above the German trader. The goods traffic alone in England and Wales is 102,066,736 tons, according to the Board of Trade Returns for 1901. Assuming that the average length of journey per 1000 tons is twenty-five miles, the English and Welsh trader pays no less than £10,206,700 more per annum, than his German competitor. While the total receipts are £25,072,936, the Germans only pay £14,866,236 for the same facilities, or a difference of 59 per cent. in their favour.

Where no competition exists to the British railway company, no preferential rates are in vogue. The reasons why the companies convey Continental goods so much cheaper per ton-mile, than home merchandise, is because of the existence of competition, and the low rates they charge in so doing, are the highest compatible for obtaining the traffic.

The steam wagon, in my opinion, is destined to alter all this, it can be made a form of competition as strong as the shipping interest. It has come to stay, and properly handled and used in the way I have suggested, would no doubt prove a means of bringing back the people to the land, of improving all round the general lot of the struggling agriculturist, and of making Great Britain more, if not wholly, self supporting in the feeding and maintenance of its population.

It is imperative, however, to inaugurate a system of co-operation, in conjunction with the introduction of the steam wagons, and thus dispense with the middle factor, whose intervention between the producer and the consumer is quite as fatal to both as the excessive railway rates exacted.

Railway Motor Cars in Great Britain.

By CHAS. S. LAKE.

THE development of the rail motor car system, since its comparatively recent introduction in this country, has been marked by a rapidity unequalled perhaps in the annals of railway traffic. So much so that what was looked upon as a more or less doubtful experiment in the latter part of 1903 has, within a space of only two years, come to be regarded as an assured success, and a valuable if not almost indispensable adjunct to the operative scheme of the railways of Great Britain.

These motor cars may be said to have been forced into existence by a cumulative chain of circumstances which, prior to the year mentioned, had established a problem the solution of which could only be found in the introduction of some method, hitherto foreign to railway traffic working, designed to meet a set of conditions which had outgrown the measures taken to cope with them, especially when viewed from the standpoint of operative economy.

The necessity of reducing, as much as possible, the working expenses of railways was never more apparent than at present, for with ever increasing rate assessments and other "outside" causes militating against them, railway boards find it increasingly difficult to maintain a position which may be described as in any degree proportionate to the expectations of the shareholders, and any method by which it is possible to effect an economy without thereby jeopardising the interests of the company should be, and doubtless is, seized upon and exploited to the fullest extent. The reduction of train mileage, especially that of an unproductive character is particularly desirable, and if this can be secured, whilst at the same time affording equal and even improved facilities to the public, a nett gain to the revenues of the company must inevitably result.

Considering more particularly suburban traffic around large centres, as distinct from branch services in country districts, the difficulty is that of meeting the conditions imposed by a greatly, even although regularly, fluctuating volume of traffic, and in providing for the widely differing requirements of certain definite periods of the day, without sacrificing economy. In the London district and at other large centres the influx of passengers during the "business" hours; *i.e.*, from 7 a.m. until 10 a.m., from the outlying suburbs is very great, and in a similar manner the course of certain hours during the evening is marked by a general exodus from the town on the part of the public. A heavy traffic is done in both directions during these periods, and in order to provide adequate accommodation, long and heavy trains, sometimes weighing. fully loaded, as much as 270 tons have to be utilised and even then run at frequent intervals in order to deal satisfactorily with the situation.

During the intervening hours, and more especially in the early afternoon, the number of passengers dwindles to such an extent that, in spite of an extensive curtailment in the train service it becomes in many cases, absolutely impossible to work on a profitable basis, whilst employing the ordinary rolling stock and make up of trains.

Under such circumstances it seems certain that, except within the most congested districts, such for instance as the metropolitan area, a service of rail autocars, each capable of fulfilling the requirements of a limited number of passengers at reasonably frequent intervals is the best and most economical system of working which can be devised,

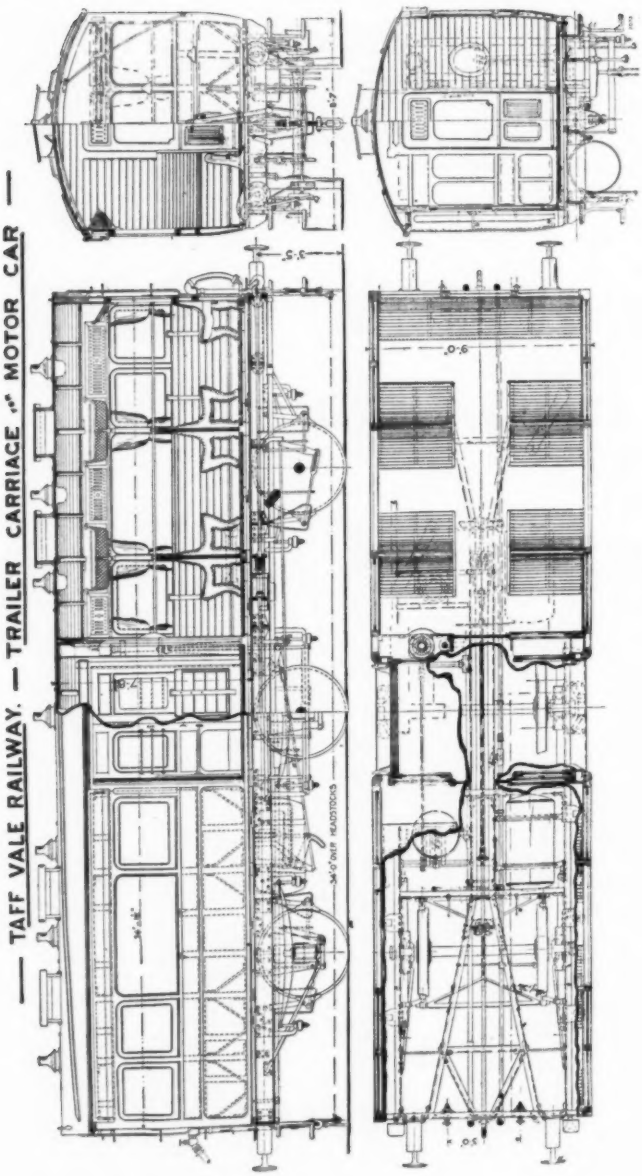


FIG. 1.

and one which is most likely to successfully combat the all too realistic bogey of tramway competition where such is being felt. This would, at all events, appear to be the case until such time as those portions of the railways which serve suburban districts have been converted to electrical methods of working.

The rail motor car system is even more applicable to railway working in sparsely populated districts, on country branch lines, and generally where the conditions are such as to render any but a meagre train service unprofitable.

Trains can only be run at infrequent intervals, to allow of the observance of economy, and this, as is only natural, leads to a determination on the part of the public to find some other mode of travelling, such as driving, cycling, or even walking rather than submit to the vexatious inconvenience of waiting the company's time. Under such conditions, the introduction of a motor car service may be confidently expected to produce excellent results, for the cars can be kept constantly at work at a cost falling considerably below that involved in running an intermittent train service.

Again, in rural districts, at points where, to provide station accommodation is obviously out of the question, it has been found advantageous to afford the public roadside facilities for entering and leaving the cars at definite points on the route, some of which are designated "haltes" at which a low platform, giving easy access to the cars is provided. In this way people are encouraged to travel where they would otherwise refrain from doing so owing to the inconvenience of journeying to the nearest station, sometimes a considerable distance away.

In other districts where traffic is well established, the cars may be used advantageously to supplement the train service at all periods of the day, thus assuring a frequency of journeys without involving a large ordinary train mileage and by this means transforming what would otherwise be a scanty service into a liberal one. In cases where a shuttle service is in vogue, with one engine and

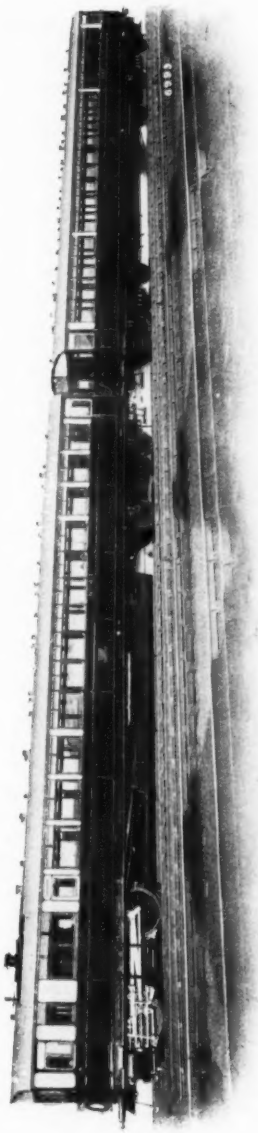


FIG. 2.—SUBURBAN-TYPE MOTOR COACH AND TRAILER, GREAT WESTERN RAILWAY.

train doing the whole of the day's work on a branch line, there is no doubt that more liberal facilities can be given and at no greater cost by the employment of the auto-car system and with a reasonable assumption that additional traffic will thereby be attracted to the line.

A few of the railway companies in this country among those which have adopted motor cars, are extending the application of the system by introducing trailer carriages, thus providing a means of largely increasing the amount of seating accommodation available without incurring the drawback of frequently hauling empty vehicles. The trailing cars can be readily attached or detached in accordance with the requirements of the traffic thus differing from a made up train of coaches running in sets from one year's end to the other.

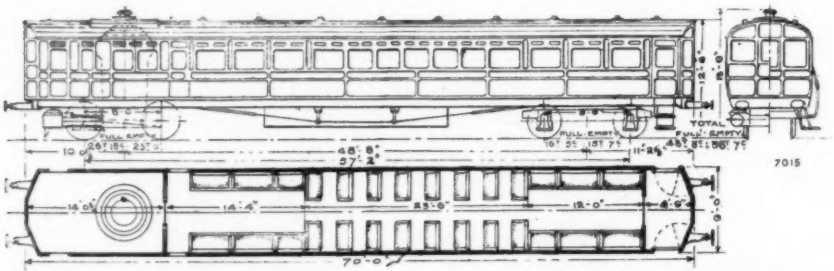
As an example of the advantages which may be expected to accrue from the introduction of the rail motor car system, it is interesting to note what has been done in this connection on the Taff Vale Railway since 1903 when the first car was put to work on the Penarth section of the line. In response to a request made by the writer, Mr. A. Beasley, general manager of the railway referred to, very kindly forwarded a statement setting forth the Taff Vale Company's experience in respect of working branch and other traffic with motor cars, and including some figures having reference to the relative cost of such working as compared with that involved under ordinary conditions. Mr. Beasley states that the cost of running a car, as compared with a train, is as follows on the Taff Vale Railway.

Running.	Motor Car (cost per train mile). d.	Engine and 4 coaches (cost per train mile). d.
Engine: Coal	1·36	3·03
Water	·12	·36
Oil and stores ...	·19	·46
Cleaning, steam raising, &c.	·19	·51
Carriages: Lighting, cleaning and oil ...	·23	·92
	2·09	5·48
Repairs, renewals, &c.	1·46	6·22
Wages	1·93	3·47
	5·48*d.*	15·17*d.*

Mr. Beasley further adds:—

(1) The company has as yet had very little experience of tramway competition and therefore the cars cannot be said to have brought back to the railway traffic which the tramways have attracted therefrom.

(2) The introduction of motor cars has had the effect of increasing the number of passengers by about 13 per cent. on the Penarth branch, and by 32 per cent. on the Aberdare branch, on which sections the cars supplement the ordinary train service, and by 11 per cent. on the Nelson and 50 per cent. on the Ynysybwl branches



Cylinders—Dia., 12 ins.; stroke, 16 ins.
Boiler—Height, 9 ft. 6 ins.; dia., 4 ft. 6 ins. and 6 ft. 0¼ ins.
Firebox—Height, 3 ft. 6 ins., dia. 3 ft. 10 ins.
Tubes—No. 462, dia., 1¾ ins.; length, 4 ft. 5¾ ins.
Firegrate Area—11·54 sq. ft.
Heating Surface—Tubes, 605·9 sq. ft.; firebox, 46·75 sq. ft.; total, 652·65 sq. ft.
Wheels—Motor, 4 ft.; bogie, 3 ft. 7½ ins
Water Tank Capacity—450 gallons.
Coal Bunker Capacity—15 cwts.
Working Pressure—160 lbs.
Tractive Force—6,912 lbs.

FIG. 3.—SUBURBAN-TYPE RAIL MOTOR CAR AND TRAILER, GREAT WESTERN RAILWAY.
(By courtesy of Editor of "Great Western Railway Magazine.")

where a service of cars has been substituted for a train service.

(3) The number of trips run by motor cars on the several branches is as follows:—

Penarth branch	42	services	each	way, daily.
Aberdare ,,	19	,,	,,	,,
Nelson ,,	12	,,	,,	,,
Ynysybwl	11	,,	,,	,,

(4) The ordinary passenger traffic of the Nelson and Ynysybwl branches is worked entirely by motor cars without trailers. The Aberdare service is also worked without them, but here the cars only supplement the train service. On the Penarth branch, where the car service is also supplementary, the company is not at the present time running trailers, but it is found that at certain hours of the day the cars are very much overcrowded and trailing cars are now being built for use on this service* The motor car service on the Taff Vale railway is exclusively a passenger service, in fact the heavy gradients, including 1 in 38 and 1 in 40 on most of the sections on which the cars are run would preclude the use, as a trailer, of a heavier vehicle than those being built.

(5) This company has had no experience of the value of rail motor cars in opening up new lines but a car service would doubtless be of great value in developing traffic in a district not sufficiently populated to make an ordinary train service remunerative.

(6) There are no means of ascertaining how many of the passengers who avail themselves of the roadside facilities would, if such conveniences did not exist, go to the nearest station or use some other means of travelling, but, judging from the general benefits to the traffic returns by the motor car service, it seems certain that the roadside facilities afforded have contributed considerably to the results attained.

(7) The company has had no experience of road motors as "feeders," nor is it at present contemplated to experiment with them for the reason that the population of the districts served by the railway lies along the course of the valleys through which the line runs, and generally speaking, within about a mile or so from the railway itself.

The motor cars used upon the Taff Vale Railway were designed by Mr. T. Hurry-Riches, Locomotive Engineer of the company and built some at the company's works and others by outside firms. Full detailed drawings of these cars were published in the *Engineering Review* for April, May and June, 1904; both of the engine and carriage portions.

Each car is 58 ft. 9 in. long over buffers, and runs upon two four-wheeled

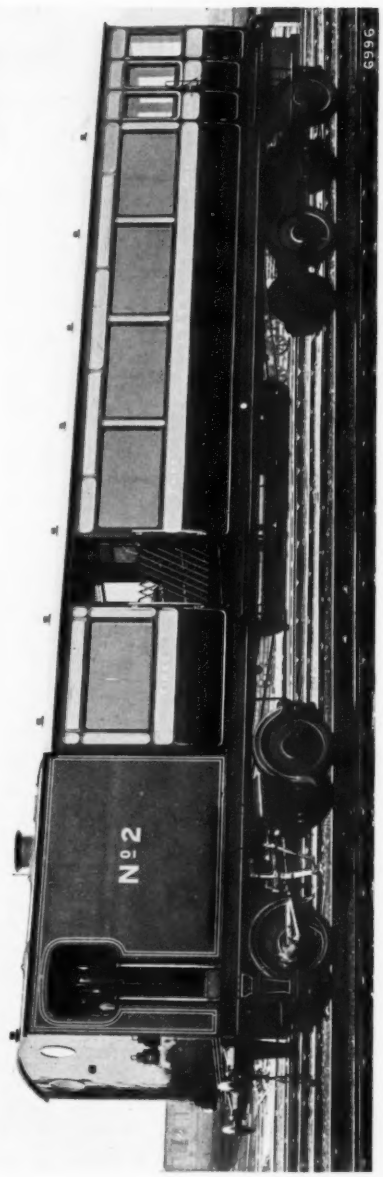


FIG. 4.—STEAM MOTOR COACH, LONDON AND SOUTH WESTERN RAILWAY.

* See illustration on page 54.

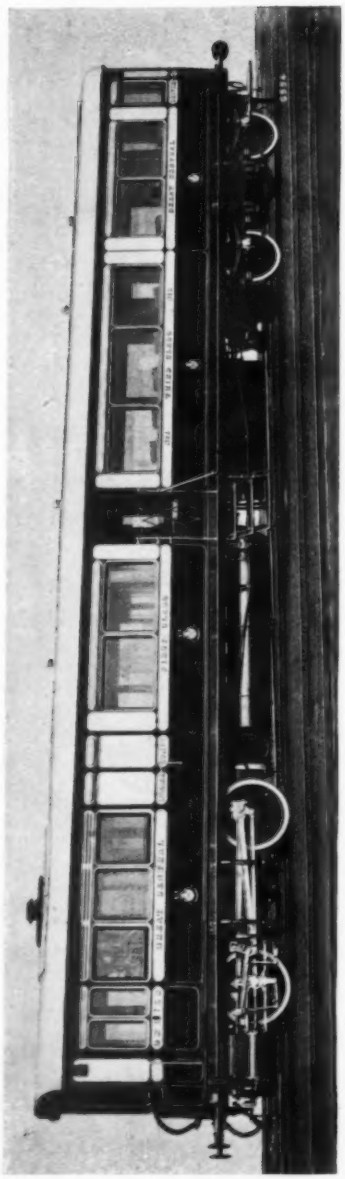


FIG. 5.—STEAM MOTOR COACH, GREAT CENTRAL RAILWAY.

bogies, spaced with their centres 40 ft. 9½ in. apart, the total wheelbase being 49 ft. 3½ ins.

Seating accommodation for twelve first-class and forty third-class passengers is provided in seven of the cars, the remainder have third-class accommodation only and in addition there is a luggage compartment measuring 3 ft. 11½ in. by 8 ft. Both of the passenger compartments are heated by steam from the engine, with warmers of acetate of soda on Peter's system and the Pintsch system of oil-gas lighting is employed.

There are two entrance gangways, both of which are fitted with steps which may be readily lowered or raised for roadside passengers.

The car framing is constructed of steel channels and angles, and stiffened by truss rods and the body and frames are suspended to the bogie frame by eight spiral springs arranged to admit of passing round a 5-chain curve.

The engine has two 9 in. by 14 in. cylinders placed horizontally outside the framing and between the wheels of the "forward" bogie; the connecting rods driving the end pair of wheels. Stephenson link motion is employed for actuating the valves, which work above the cylinders, through the medium of a rocking shaft. The boiler is of the multitubular type constructed of steel plates with a copper firebox. There are 312 tubes of 1¾ in. diameter; the total heating surface is 338·5 sq. ft. and the grate area 8 sq. ft.

The boiler carries a working steam pressure of 160 lbs. per sq. in. and has two 3 in. safety valves mounted upon the dome. The engine bogie has wheels 2 ft. 10 in. diameter arranged on a base of 9 ft. 6 in. (except in No. 1. car in which it is 8 ft. 6 in.) and the water capacity of the tanks is 530 gallons, whilst 10 cwt. of coal is carried in the bunker. At 80 per cent. of the working pressure the tractive force is 4,263 lbs.

Fig. 1 illustrates one of the new trailer coaches now being built for use in conjunction with the motor cars on certain branches. These vehicles run upon six wheels and have two passenger

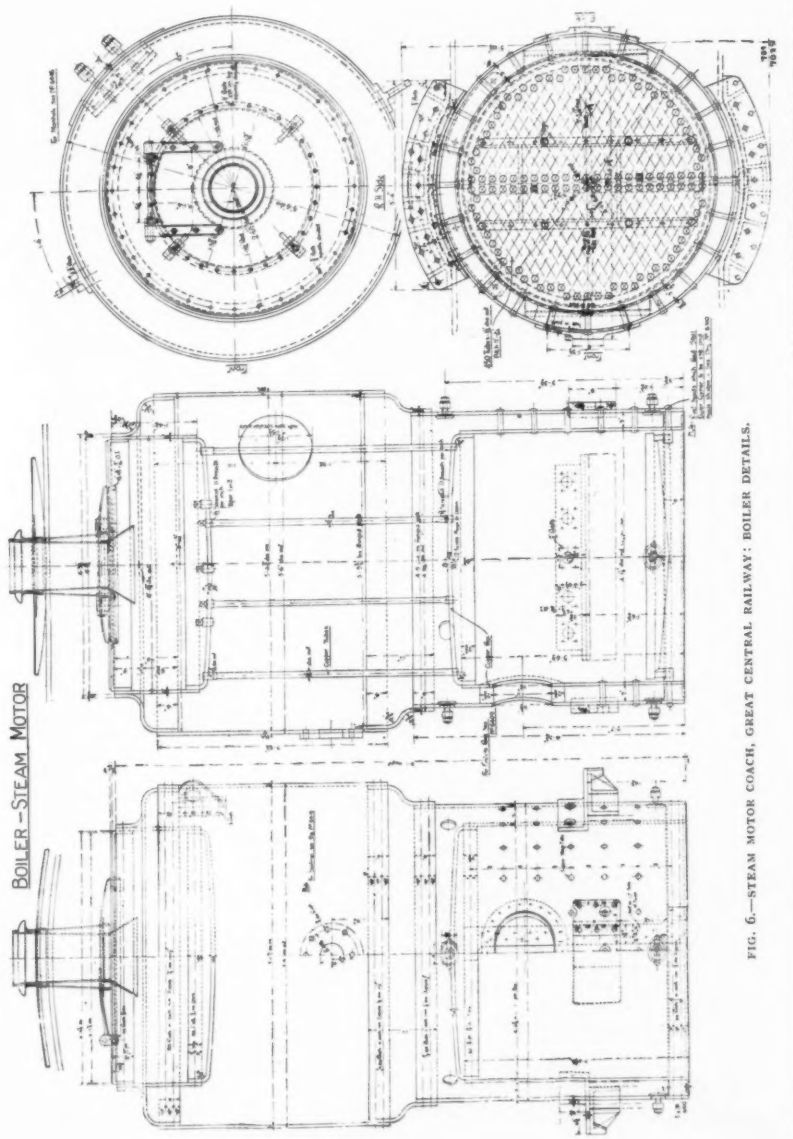


FIG. 6.—STEAM MOTOR COACH, GREAT CENTRAL RAILWAY: BOILER DETAILS.

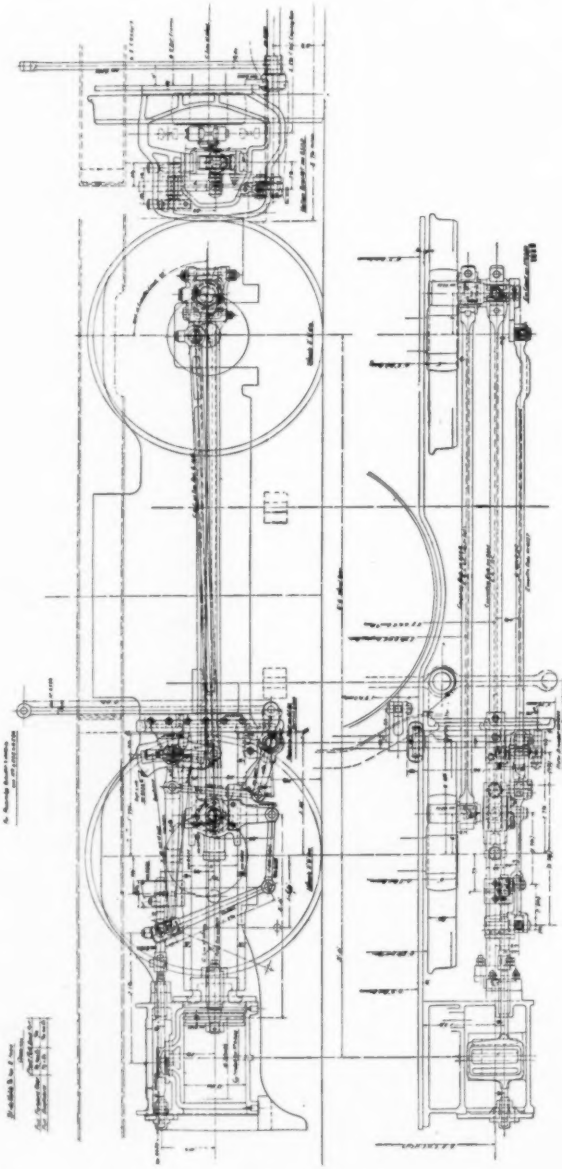


FIG. 7.—STEAM MOTOR COACH, GREAT CENTRAL RAILWAY: ENGINE DETAILS.

compartments, separated by a combined vestibule and luggage compartment in the centre of the car fitted with double doors on each side. Seating capacity for forty-two passengers is provided and the seats are arranged at the sides of the carriage, back to back in pairs, with a central passage between them. At the ends of the vehicle the seats extend across the full width and provide accommodation for five passengers each. The carriage runs upon wheels 3 ft. 7 in. in diameter with a total wheelbase of 20 ft. The equipment includes steam heating and electric bell communication between the trailer and the motor car. Gas lighting is employed. The carriage measures 37 ft. long over headstocks and is 9 ft. wide over all.

On the Great Western Railway the rail motor car system has been developed to a stage wholly unapproached on any other line in the country, and in addition to this the company has also established a road motor service operating in districts adjacent to the railway system in ten separate counties. The rail motors are employed in twenty-one different sections of the line in Middlesex, Berkshire, Wiltshire, Cornwall, Glamorgan, and other counties. The cars are of two different types known respectively as "Suburban" and "Branch" cars, the former designed to serve districts of an urban character and the latter for use on country branch lines. The cars are sufficiently powerful to haul a number of trailing vehicles, such as horse boxes, goods trucks, &c. On a few branch lines traffic is entirely worked by rail motor cars but the employment of the cars for operating goods traffic has not,

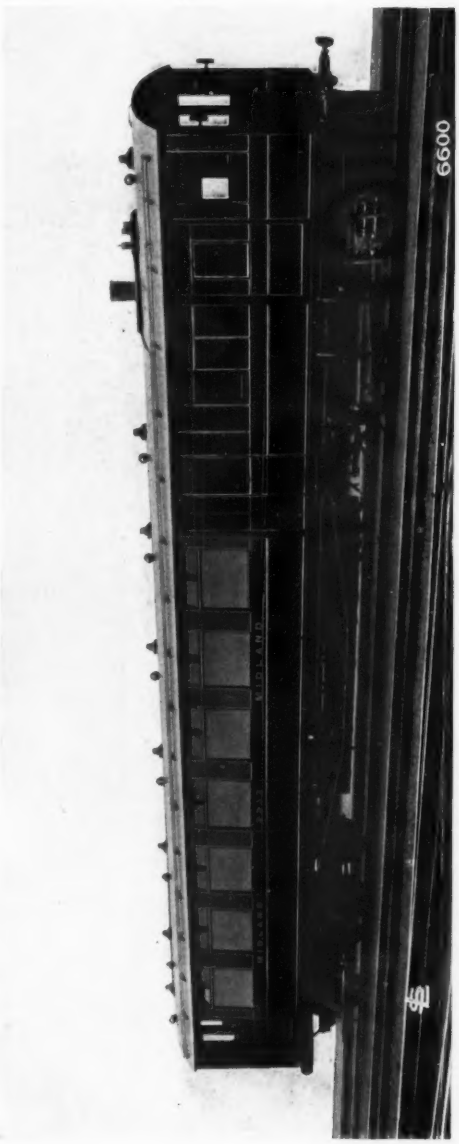


FIG. 8.—STEAM MOTOR COACH, MIDLAND RAILWAY.

FIG. 9.—STEAM MOTOR CAR, SOUTH EASTERN AND CHATHAM RAILWAY.

so far, been found practicable. Some large trailing cars have recently been built at Swindon works.

Fig. 2 gives a good impression of the appearance of one of the latest suburban type cars with the trailer coupled to it. The diagram (Fig. 3) shows the general internal arrangement of the motor car.

A smoking compartment with seats placed longitudinally occupies a position next to the motor room and the next in order is the main saloon containing sixteen double transverse seats, the backs of which (except in the case of the end seats), are reversible. The following compartment is similar to that next the motor room, being provided with longitudinal seats with arm rests at intervals. The vestibule with side doors and steps is situated next, at the extreme end of the car. The engine bogie is fitted with outside cylinders 12 in. diameter by 16 in. stroke with valves, actuated by Walschaerts' motion working above them. The wheels are coupled together by side rods; they are 4 ft. in diameter and occupy a wheelbase of 8 ft. The car bogie has 3 ft. 7 in. wheels spaced 9 ft. apart. The boiler is of the vertical multitubular type with cone top. It contains 462, $1\frac{1}{16}$ in. diameter tubes and has a total heating surface of 652·65 sq. ft. The grate area is 11·5 sq. ft. and the working steam pressure 160 lbs. per sq. in. Other dimensions appear on the diagram.

The London and South Western Railway Company, although pioneers (in conjunction with the London Brighton and South Coast Railway) in the matter of rail motor cars have not, so far, followed the matter up to the extent of some of the other railways. The first car to be introduced in this country was put to work in June 1903 on the joint branch line between Fratton and Southsea, and similar cars are now being run by the South Western Company on the Turnchapel and Bishops Waltham branches. Fig. 4 illustrates the design, which is that of Mr. Dugald Drummond, Chief Mechanical Engineer. The boiler is of the locomotive type

arranged with the firebox at the leading end and enclosed in a somewhat spacious "cab." The engine cylinders are carried outside the bogie frames in an inclined postion, and they drive the end pair of wheels. Walschaerts' gear is used for operating the slide valves which work on top of the cylinders. The capacity of the water tank is sufficient for running 60 miles without replenishing and enough coal for a complete normal day's working is accommodated at one loading. The carriage portion has accommodation for eight first-class and thirty-two third-class passengers and space for one ton of luggage is provided in a separate compartment. The cars are worked by two men only and can be driven equally well from either end, the men taking turn and turn about every other week at the engine end. The principal particulars are as follows:—

ENGINE.

Cylinders, 9 in. dia. by 14 in. stroke.
Wheels, 3 ft. dia.
Working steam pressure, 175 lb. per sq. in.
Tank capacity, 530 gallons.
Coal, 1 ton.

CAR.

Passenger accommodation, 40 persons.
Luggage, 1 ton.
Length over buffers, 51 ft. 2½ in.
Length between bogie centres, 33 ft. 1 in.

Rail motor cars have been introduced upon several other British railways, the majority of them quite recently. Among those which have taken this step are the Great Central, Midland, South Eastern and Chatham, and Furness, whilst the Great Northern and L. & N. W. Railways both have cars in course of construction at the present time. The type of car used on the Great Central Railway is illustrated in Figs. 5, 6 and 7. The length over headstocks is 61 ft. 6 in. and there are several compartments which are arranged in the following order:—viz., Motor compartment, luggage room, first-class compartment, third-class ditto, third-class smoking compartment, and drivers end compartment.

A transverse vestibule fitted with collapsible gates separates the first from

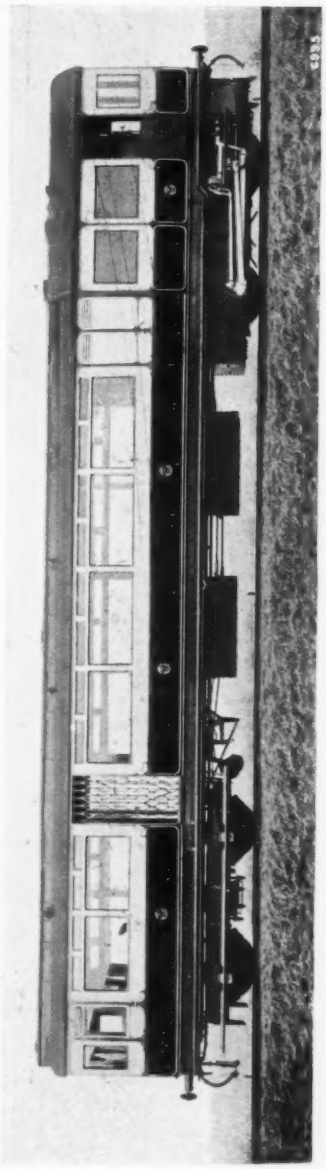


FIG. 10.—STEAM MOTOR CAR, FURNESS RAILWAY.

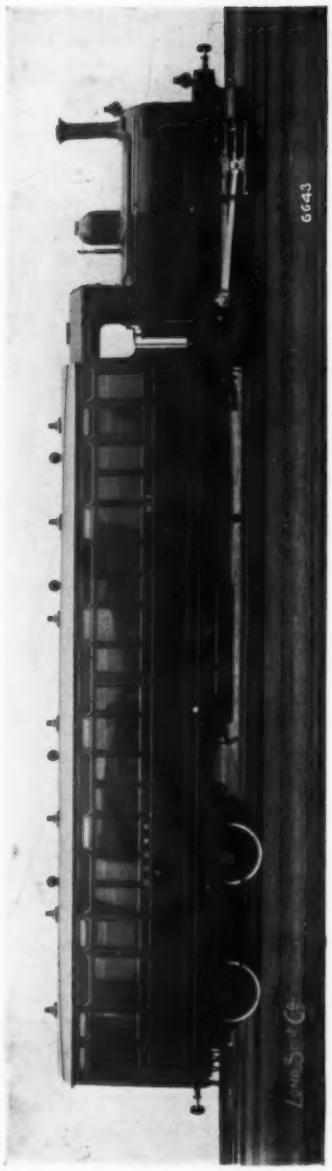


FIG. 11.—STEAM MOTOR CAR, GLASGOW AND SOUTH WESTERN RAILWAY.

the third-class accommodation and steps are provided, affording a means of access to the car either from the platform or road level.

These steps are hinged so that when not in use they swing back to the width of the ordinary footboard but when required are forced outwards being actuated by levers in the gangway. Accommodation for twelve first and forty-four third-class passengers is provided, with space for a reasonable quantity of luggage.

The engine bogie is fitted with outside cylinders and Walschaerts' valve gear is employed for operating the valves. The boiler is of the vertical multitubular type and contains 450, $1\frac{1}{4}$ in. diameter tubes. The steam regulator, whistles, vacuum and hand brakes are governed by the driver from either end at will according to the direction in which the car is travelling. Electric lighting is used and the dynamo for supplying the current is belt driven off a pulley fixed on one of the car bogie axles. The coal is stored in the motor compartment and the water is carried in tanks suspended from the underside of the frame, as are also the accumulators and dynamo used in connection with the electric light. The cars were designed by Mr. J. G. Robinson, Chief Mechanical Engineer, Great Central Railway, and built at the company's works at Gorton, near Manchester.

The Midland cars, one of which is illustrated in Fig. 8, have already been described in these pages,* but a brief notice of the design will not be out of place at this point. Each coach is divided into four sections, viz., engine room, passenger compartment, luggage compartment and vestibule.

The total seating capacity is for fifty-five passengers all of one class, the seats being arranged transversely with a central gangway running the entire length of the saloon.

Folding seats for eight additional passengers are also provided in the luggage compartment. Entrance to the car is effected by a door in the compartment next the engine room, and also by

* *Engineering Review*, October, 1904.

means of a sliding door giving access to the saloon from the vestibule. Doors are provided at each end so as to afford through communication when a trailer is in use.

The engine has two horizontal cylinders, 11 in. diameter by 15 in. stroke, driving the end pair of wheels on the engine bogie, both pairs being coupled together by side rods. Walschaerts' motion is used for the slide valves, which work above the cylinders. The controlling gear is duplicated so that the car can be operated with equal facility from either end, the connections being flexibly arranged for rounding curves, &c. The boiler is of the vertical multitubular type, with a total heating surface of 498 sq. ft., and a grate area of 11·3 sq. ft.; it carries a working steam pressure of 160 lbs. per sq. in. The bogie wheels are 3 ft. 7½ in. diameter with a wheelbase of 8 ft. The two bogies are placed with a distance between centres of 42 ft. and the total wheelbase is 50 ft. The car weighs, empty, 32 tons 6 cwts. 1 qr., and loaded, 36 tons 1 cwt. 1 qr. It is capable of a speed of 30 miles per hour and the tractive power of the engine is 5,000 lbs.

The use of steam motor cars upon the South Eastern and Chatham Railways is at present confined to the employment of two such cars working, one upon the Sheppey Light Railway, a line 8¾ miles long, between Queenboro and Leysdown, and the other upon the Hundred of Hoo branch, between Gravesend and Port Victoria. In this design the engine takes the form of a small tank locomotive which is so arranged that it may readily be attached to or detached from the car itself (Fig. 9).

The engine is carried on a four-wheeled bogie, the centre pivot being fixed to a cross-beam at the end of the carriage underframe. The cylinders, which have a diameter of 10 in. and a piston stroke of 15 in. are placed outside the frames and the wheels are coupled together. The valve gear is of the Walschaerts' type. The boiler is fitted with a Belpaire firebox and has a total heating surface of 381 sq. ft. of

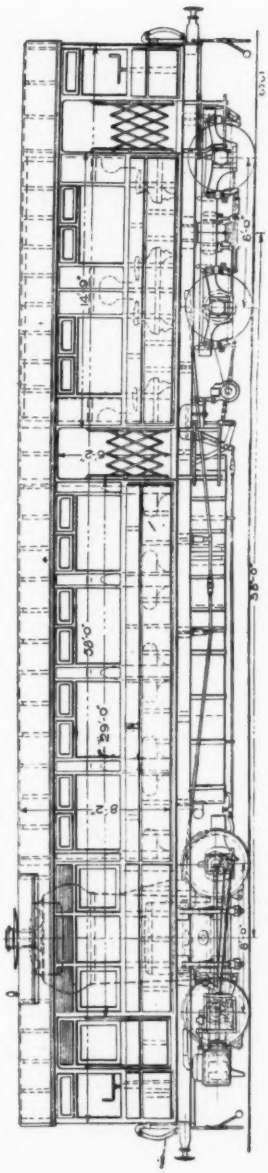


FIG. 12.—STEAM MOTOR CAR, GREAT NORTHERN OF IRELAND RAILWAY.

which 44·5 sq. ft. is in the firebox, and 337 sq. ft. in the tubes; the grate area is 8·8 sq. ft. and the working steam pressure 160 lbs. per sq. in. Water tanks are placed at the sides of the boiler and between the bogie frames; the total capacity being 400 gallons, the coal bunkers are at the ends of the side tanks and carry about fifteen cwts.

The car is capable of hauling an additional trailer carriage, weighing sixteen tons, at a speed of over thirty-five miles per hour on the level, and at an average speed of thirty miles per hour including gradients. The carriage body is 48 ft. 4 in. long outside and is divided into three compartments. The vestibule is placed at the end, next to the engine, and the luggage compartment has hinged doors opening inwards; sliding doors are arranged in the passenger and guards compartments. The seats are placed back to back with a gangway down the centre. The accommodation is for thirty-two non-smoking and twenty-four smoking. The car underframe is of steel and is carried at one end by a four-wheel carriage bogie, with a wheel base of 8 ft. and 3 ft. 6 in. diameter wheels; the other end being supported on the engine bogie and cushioned with india-rubber pads. The equipment includes the vacuum automatic brake, and a hand brake on the carriage and engine. Stone's system of electric lighting and electric bell communication. The car, which can be operated from either end, has a total weight of about 38 tons, unloaded.

Fig. 10 illustrates a steam motor coach built at the works of the Furness Railway from the designs of Mr. W. F. Pettigrew, locomotive and carriage superintendent. This car is employed for running between Ulverstone and Lakeside, a distance of about ten miles.

The boiler is of the locomotive type enclosed and placed with the firebox in front, so that the driver may obtain an uninterrupted view ahead. The cylinders are 11 in. by 14 in. and they drive the rear pair of engine bogie wheels, which are 2 ft. 10 in. diameter on the tread. The bogie centres are placed 40 ft. apart and the total wheelbase is 48 ft. The controlling mechanism, vacuum, steam and hand brakes can be operated from either end.

The car is lighted by electricity and heated by steam; the water tank, which holds 300 gallons, is carried under the carriage body and coal is stored in the engine compartment. The total length over buffers is 60 ft. 11 in. and seating accommodation for twelve first-class, and thirty-six third-class passengers is provided, with luggage space in addition.

At present only one of the Scottish railways is employing the rail motor system, viz., the Glasgow and South Western, and the cars designed by Mr. James Manson, locomotive and carriage superintendent are very similar in appearance to those designed by Mr. Wainwright for the South Eastern and Chatham Railways, and illustrated in Fig. 11. The engine is a four-wheeled coupled locomotive with outside cylinders, but in this case the valve gear is of the ordinary link motion type, inside the frames, instead of Walschaerts', outside. The engine and car bogies are of the suspension link type, with 3 ft. 6 in. diameter wheels, and a wheelbase of 8 ft. in each case. Both vacuum and hand brake apparatus, which, in conjunction with the other mechanism can be operated from either end of the car, is fitted to each bogie. The car is 60 ft. 8 in. long over buffers, and is divided into four compartments. Steps are provided at the guards compartment, to enable passengers to enter from the road level, the steps being raised or lowered as required, by means of a lever.

Accommodation is provided for fifty persons. The following are the chief dimensions of engine and car:—Engine cylinders, 9 in. by 15 in.; engine wheels 3 ft. 6 in. diameter; boiler heating surface (total) 440 sq. ft.; boiler grate area, 8 sq. ft. The water tank is carried below the frame, and has a capacity of 500 gallons and a fuel space for fifteen cwt. of coal is provided. The length of the vehicle over headstocks is 57 ft. 2 in. and over body, 41 ft; distance from centre to

centre of bogies, 39 ft. 4 in. Total wheelbase 47 ft. 4 in.

Three of the more important railways in Ireland have recently introduced rail motor cars, viz., the Great Northern, Great Southern & Western, and Belfast & County Down.

One of the cars employed upon the first named line is illustrated by diagram in Fig. 12. There are three compartments and two vestibules. The motor end is suspension hung from the engine bogie frames, and the vestibule end is carried upon a four-wheeled Fox's pressed steel bogie, with 3 ft. 7 in. diameter wheels.

The bogies are placed at 38 ft. between centres and the total wheelbase is 46 ft. The underframe is of steel and is 58 ft. long over headstocks, by 8 ft. 7 in. wide spread out to 9 ft. at the motor end. The vestibules are fitted with collapsible gates, and long commode handles are provided at each entrance and at the motor compartment. The engine cylinders are 12 in. diameter by 16 in. placed horizontally outside the bogie frames and driving the trailing pair of wheels, which are coupled to the end pair. The valve motion is of the Walschaerts' type. The boiler is of the vertical multitubular type with cone top, 5 ft. 11 in. diameter inside the largest ring, and 9 ft. 6 in. high. The working pressure is 175 lbs.; the height from rail to top of chimney 13 ft. 2 in. The cars are lighted on Stone's system, including the head and tail lamps. The equipment includes steam heating and electric bell communication. The cars work on local branches between Dublin and Howth, and Belfast and Lisburn.

The whole of the foregoing examples of motor coaches on British railways are alike in one important respect, viz., in the method of propulsion. In every case steam is the agent employed and there is every indication that cars so propelled will continue to find favour in this country. On the Great Northern Railway a petrol car is being experimented with and has in fact been running, although not in regular passenger service, for some time. The new vehicles building for this line will, however, be steam driven in the same manner as those on other railways.

The North Eastern have in service a few electric auto-cars but these are the only ones of their kind used in this country.

They have seating accommodation for fifty-two passengers and a four-cylinder "Wolseley" petrol engine of 80 B. H. P. is employed for generating power for driving purposes.

The weight in working order is thirty-five tons, length over headstocks 52 ft. and extreme inside width 7 ft. 11 in. A detailed description with drawings of these cars has already appeared in the pages of the *Engineering Review*.

Rapid Transit in Small Towns.

By T. CLARKSON, A.M.Inst.C.E.

THE important question of improved rapid transit in small towns has been given further impetus by the recent development in the application of motors to road vehicles, and the municipal authorities are now presented with an alternative to the installation of a costly and cumbrous tramway system.

Rapid transit for both passengers and goods becomes more and more imperative and essential to the conditions of modern life in both town and country. Unquestionably the electric tram has done much to develop rapid transit. Its best friends and admirers must, however, admit its serious drawbacks in the monopolisation of the road to the detriment of other classes of traffic, and in the almost intolerable nuisance of having the roads torn up and kept in an unfit and generally dangerous condition for many months during the laying down of the rails. In addition to this, one has to consider the enormous expenditure which this work entails, added to the cost of the overhead equipment, and the provision of an expensive central power station.

The advent of the motor 'bus opens up possibilities of overcoming these serious drawbacks, and those responsible for municipal expenditure and administration may well pause before going further in their tramway schemes.

The motor 'bus has not long been before us in a practical form, but it is rapidly assuming a workmanlike shape, and I can see no reason why it should not do all that is required for the rapid transit of passengers both in town and country, and without giving cause for those reasonable objections on the score of noise, smell and dust, to which motors at present give rise.

Many of the motors hitherto placed upon the road certainly do not commend themselves to the public, or to the unbiassed engineer, but the enthusiast may not be disposed to admit that there is any room for improvement or any cause for criticism. Candidly, however, I see no reason for denying that many of the devices hitherto placed upon the road are distinctly crude, noisy and objectionable contrivances, and the public has a right to something very much better, which it goes without saying they will duly get.

The patient indulgence extended by the public to these early types is, I think, very commendable, and is doubtless tempered by the belief that the developments of the road motor will be productive of great advantages, and it is therefore worth their while to extend to them a certain measure of consideration.

The imperfections are, to a large extent, dependent upon the birth of a new era, and when these have ceased, and the new order of things has settled down, I have no reason for doubt that the motor will, to a very large extent, if not entirely, supersede the electric tramway.

At the present time it may be said there is a war of types, that is to say, there are partisans of the steam motor, and those that believe that the petrol motor is the only one that will survive.

It is probable that each type has its legitimate sphere. Personally, I am convinced that, for public service work, steam will be able to hold its own. In places where steam omnibuses are now running, a marked preference is shown for them by the public in view of their smoothness of action, general quietness, and freedom from odour. By the entire absence of change speed gears and clutches passengers secure greater

comfort, and immunity from jar and jerk, and the driver, who in this connection is a most important individual, is granted greater freedom of action and much easier control.

Another point of serious import in this question of the type of motor rests upon the nature of the fuel used in the two systems. The steam car is able to use the ordinary grades of pretroleum employed for domestic illumination and general purposes. Very large supplies of this fuel are already available, and the addition of several million gallons per annum in the rate of consumption is not calculated to make much disturbance in the supply and price.

On the other hand, the supply of petrol is relatively small. It is moreover, in the hands of a few people, and the price is liable at any time to fluctuate largely, and may reach a figure which places it practically outside the pale of consideration for public service cars. Even at the rates already obtaining between petrol and paraffin, and in view of the theoretical difference in the efficiency between internal combustion and external combustion motors, the difference in cost per mile is to the advantage of the well built steam car.

Added to this, is the by no means small consideration of safety and practical immunity from fire risk. It is not perhaps generally known that paraffin does not give off inflammable vapour at the ordinary temperature. This may be easily tested by throwing a lighted match into paraffin contained in a saucer, when the match is promptly extinguished. The same thing tried with petrol results in instant conflagration.

Should a collision occur and result in perforation of the fuel tank, in the case of petrol the result would be most serious, as it is almost certain to ignite, and owing to the rapidity with which the flame will spread on the ground, it is likely to involve other users of the road in its immediate vicinity. In the case of paraffin, however, this is not likely to occur.

Nor is this fire risk appreciably lessened by the substitution of alcohol, as is now proposed.

The advent of motors is experiencing the usual opposition of ignorant prejudice, and it is to be feared that the selfish indulgence in high speeds by private users, rather fosters than ameliorates this attitude. In my opinion this prejudice will be most effectually overcome by the public service motor, which is in the fullest sense the motor for the "man in the street," and when he realises that the motor has become his own conveyance which he can employ to carry him in safety and comfort to any place he wishes to go, he will quickly forget his antipathy to the private user of motors, caused by any danger or inconvenience he may previously have suffered.

The employment of trams is quite intelligible so long as the tram appears to be the only available method of improved means of transit, but now that the self-contained motor has demonstrated its capabilities, and is being rapidly brought into the front rank of mechanical efficiency, I consider it would be most unwise for any small town to go in for a tramway system, if not already adopted, or even to spend money on extensions.

The tramites seek to justify the costliness of their installation upon the grounds that even with such a large initial outlay it is possible to run a cheap service. But it can be shown that even better transportation facilities than the tram affords can be provided by motor 'buses, at less than one-third the cost.

Omnibuses are criticised because they do not carry so many passengers as the tram, and it is therefore inferred that they are consequently unsuitable for dealing with a large volume of traffic. But it is surely better from the public standpoint to have a more frequent service, with, say, double the number of omnibuses, capable of carrying thirty-five to forty passengers each, instead of half the number of big trams, each with seventy or eighty seats.

To begin with, a passenger has only

half as long to wait for a car, and the smaller car is able to do a more rapid average service than the tram, since with only half the number of passengers, it has only half the number of stops.

Witness the frequent sight in our main thoroughfares of long lines of trams, all at a standstill, and for all practical purposes crippled, because of the failure of a single one, or because of an obstruction on the line.

We are not likely to be familiarised with such a line of crippled motor buses in our streets. Individual failures may occur, yet these are becoming more rare as the motor 'bus evolves into a settled type; but, should the route be blocked, the 'buses can take another, and maintain the service without interruption.

In conclusion, the question may be summarised as follows:—

1. With equal aggregate seating capacity, a service of motor 'buses is far cheaper to instal.

2. The 'bus can give a quicker and more frequent service.

3. The 'bus does not require roads to be torn up and monopolised, but one uniform good road surface is available to the advantage of all.

4. The 'bus is flexible in operation. If the first 'bus stops the following can pass it, and if one route fails another can be used.

These advantages are powerful, and command the attention of those interested in transportation for both town and country.

A word of caution may be necessary against the adoption of imperfect types, yet the motor 'bus is surely forging ahead, and the technical difficulties of the subject are steadily overcome by persistent skill and courage. The result, I believe, will be favourable to the British engineer.

The Position of the Electric Automobile.

By THEODORE G. CHAMBERS, Assoc.R.S.M.

No one who has watched the development of the electric carriage in this country during the last two or three years can have failed to note that this type of auto-car has reached a high pitch of mechanical perfection.

In congested town areas where high speeds are not possible or desirable, and in circumstances where the limited range of the electric carriage upon one charge of its accumulators is no disadvantage, it is almost perfect as a self-propelled carriage.

Except in the direction of an improved type of accumulator, it is indeed difficult to foresee any further developments. The electric motor itself is highly efficient and elastic. The system of control is simple and effective, and the mechanism transmitting the motion to the road wheels is silent and economical, while the small number of moving parts in the whole machine conduces to a low cost of upkeep.

The battery question is not as difficult a problem as writers on the subject in the past would lead one to suppose. It has been usual to blame the accumulator when anything went wrong, but bad

financial methods and false aims have, combined to act as a more powerful brake on the development of the electric carriage than the absence of the perfect accumulator.

It is true that batteries require a large amount of expert care and attention, but they do not give more trouble than horses, nor are they any more delicate if properly treated. The lead accumulator is to-day very well understood, and with reasonable precaution and the selection of a suitable type of plate, the cost of accumulator renewals may be kept as low, if not lower, than that of tyre maintenance. Generally speaking, a plate that is cheap and fairly durable will give better commercial results than an expensive plate with a longer life. The lead plates in use to-day give from 10 to 12 watt hours per pound. The battery usually forms about 33 per cent. of the total weight of the carriage. At speed varying from 12 to 15 miles an hour, a distance of from 35 to 40 miles is obtained upon one charge of the batteries. Such a range is amply sufficient for most purposes in an urban area. Where longer distances are required, a system of interchangeable batteries is adopted.

The Edison or Junger nickel-iron batteries have not been tried a sufficiently long time for any opinion to be given as to their future commercial value in connection with electromobiles. Certain serious disadvantages attend their use. The electrolyte—caustic potash—is a rather more objectionable material to deal with than sulphuric acid. As far as can be judged, quite as much expert attention will be necessary as the lead battery now requires. The voltage is so low that seventy cells will have to be used where forty-four now suffice, while the relation of bulk to capacity is entirely in favour of the lead battery. At present the cost of the nickel-iron cell renders it almost prohibitive, and very full proof of its durability will have to be produced to warrant the heavy capital outlay which will be entailed by its adoption.

Although the first commercial electric vehicle was constructed as early as 1886, very little progress was made until the proper field for its development was found.

The formation of an electric cab company in 1897 and its failure after about a year's work had a depressing influence on the industry. Many reasons have been given for its want of success; it is, however, sufficient to say that it was a fundamental error to attempt to run a public cab service without the guidance of any reliable data as to cost.

The expenses of upkeep were increased by the fact that almost every part of the machine was at that date experimental, and the receipts were limited by the ordinary cab tariff. The financial resources of the company being insufficient to pay for these initial mistakes, its early end was hardly surprising.

The modern petrol automobile has reached its present stage of development largely at the expense of the rich amateur who was prepared for the sake of the sport to buy a machine far from being intrinsically worth the money paid for it. When it wore out or broke up, he bought a later model, and manufacturers benefiting by the experience of their customers were thus kept busy improving their types.

These firms would scarcely have reached their present position had they in the early days of the industry undertaken the maintenance of their machines, or taken upon themselves to run them under the drastic and rigid conditions of public service.

The electric carriage, being of an essentially utilitarian character, was obliged to develop on different lines. For some time manufacturers attempted to build electric touring vehicles and racing cars, but without success, and it was not until they turned their attention to the production of a town carriage that they began to make any serious headway. About three years ago the electric brougham or landaulette became popular in London. It met a want and was found to be convenient and reliable, but expensive. Purchasers were, however, found wealthy enough to pay a

high price for the luxury. A considerable inducement to purchase was the fact that the manufacturers had sufficient confidence in their carriage to agree to maintain it in an efficient running condition upon contract. In these circumstances the industry made rapid strides, and although there are only two or three firms in this country manufacturing electric carriages, there are already some five or six hundred vehicles to be found running in London to-day.

It is true that the cost of keeping and maintaining an electric carriage has up to the present been high. Not only are the existing garages in expensive neighbourhoods, but manufacturers have been obliged to charge such a figure for maintenance as would provide for all risks of mechanical replacements. It may, however, be confidently stated that the experimental and expensive days of the electric carriage are passed. The machines have proved themselves not only unrivalled as town carriages, but also remarkably reliable owing to the system of periodical expert examination possible under the garage system. As the number of garages increases particularly in less expensive quarters of the town, and as costs are reduced by the elimination of weak mechanical elements, and parts which are expensive to maintain, so will the expense of upkeep be reduced. The manufacturer of the electric carriage, has derived an enormous advantage from his courage in undertaking the maintenance of his own machines. He actually knows what they cost to maintain, and every improvement that he has introduced has been made with a view to reducing the cost of upkeep. Cost of maintenance rather than first cost has been his leading motive, and the result has been the production of a machine whose running costs can be guaranteed with that confidence which can alone be derived from reliable data accumulated over a considerable period of time. It may be accepted as an axiom that the town carriage of the future will be the vehicle which costs least to run and maintain, and which will keep in running order during the largest number of years. More especially will this be so in the case of the trade vehicle. The man who thinks of buying a van for trade purposes does not consider so much the first cost as he does his annual balance sheet, and unless he can be offered proof that his expenses will be reduced by adopting motor traction, he will certainly keep to his horses.

The cost of running an electric carriage or van will be found to compare very favourably with the cost of running any other type of vehicle.

The accumulator driven vehicle is occasionally criticised on the ground that the power which moves it has to pass through so many phases from the burning of coal to the turning of the wheels that the incidental losses must render the vehicle economically unsound, and comparison is made with the petrol-driven car where the power derived from an explosion is transmitted almost directly to the road wheels of the vehicle. Such a criticism is plausible and would be sound if mechanical and financial efficiency were interchangeable terms.

It would appear on first thoughts that it should be cheaper to produce in a part of the vehicle itself energy direct from chemical action and to immediately use this energy as a means to propel the vehicle, than to go through the process of burning coal to produce steam to actuate an engine which in its turn shall drive a dynamo to generate electric power, which power in many cases has to be transmitted through miles of cable at the end of which it is used to produce certain chemical changes in an accumulator, this accumulator being then carried upon the vehicle to give up the stored energy when required. On investigation, however, we find that the comparative cost of these two processes in the terms of pence per carriage mile, is not unfavourable to the electric carriage.

At speeds varying from 10 to 16 miles an hour the accumulator car of to-day,

weighing 30 cwt., will run three carriage miles per Board of Trade unit put into the battery. The unit of electricity may be reckoned for commercial purposes in any large city at one penny or less. We thus have a figure of ·33 of a penny per carriage mile as the cost of the power used to propel the electric carriage. This would correspond to the petrol car running 18 miles on a gallon of petrol at 6*d*. a gallon, figures which are almost unobtainable in commercial practice.

The cost of the maintenance of the mechanical parts (including labour and materials) of the electric carriage are extremely low, and in practice have been found not to exceed a penny a mile over several years running. The cost of tyre maintenance is a high figure, and it is impossible to rate the use of pneumatic tyres at less than 2·5*d*. per mile. With solid tyres, the cost may be reduced to between a penny and three half-pence per mile, but probably at the expense of adding another half-penny a mile to the mechanical costs.

The present cost of the renewal of the accumulator plates is also high, being 2·5*d*. per carriage mile, but here, considerable reduction may be looked for in the future by the general adoption of a standard size of plate and by manufacturing in larger quantities.

Summarising the cost of running an electric vehicle we have

Power, say.....	·50	pence per carriage mile.	
Mechanical upkeep...	1·00	do.	do.
Accumulator renewals	2·50	do.	do.
Pneumatic tyres	2·50	do.	do.
	6·50	do.	do.

or, on a basis of 6,000 miles per annum, £162 10*s*. 0*d*. Adding to this the cost of a driver, £75 per annum per carriage, and stabling £20 per annum per carriage, we have a total cost of £257 10*s*. 0*d*. per annum per carriage, running 6,000 miles as against £350 per annum, which may be taken as the lowest average annual cost of a similar horse-drawn vehicle. As we have pointed out, this figure will probably be considerably reduced in the case of an electric carriage. It is certainly capable of a further reduction of 2*d*. per mile run or £50 per annum in items of tyres, and battery renewals. Admitting that the electric carriage is of such a simple character that a man can safely be placed to drive it without any previous mechanical training, and considering the ease with which a large number of electric vehicles can be economically and efficiently garaged in a single depôt, it may safely be assumed that it will find a prominent place in the solution of the question of urban traffic.

The London Traffic Problem.

By J. CLIFTON ROBINSON, A.Inst.C.E., M.I.E.E.

LONDON still awaits the report of the Royal Commission appointed to inquire into one of the greatest and most complex problems ever presented for solution. I have no intention of offering any suggestion as to the probable nature of the conclusions to be embodied in that document, but feel sure that they will be of the utmost value to all who are endeavouring to improve the traffic facilities of the metropolitan area. This will be particularly the case if the report should contain a recommendation in favour of a permanent court or tribunal for the purpose of regulating and co-ordinating all forms of vehicular traffic and of dealing with all future transport schemes.

My own views on this subject have

already been made public, and, as I stated in the evidence I gave before the Commission, I distinctly favour the creation of a permanent central authority to deal specially with London, with the proviso that no scheme within the sphere of influence of "Greater London" should be deemed to be outside the jurisdiction of the new tribunal. A line of demarcation might easily be drawn between London communications and great railway schemes by confining the definition of the former to lines not running further than into the immediately surrounding counties. Or a London line might be defined as one coming within the metropolis, or any line forming a physical junction with such line for the purpose of affording direct through-facilities of transit. By dealing with the matter in this way the whole of London would be kept apart from the rest of the country, while co-ordination would be obtained for all proposals really affecting the metropolitan area.

Bearing in mind the present chaotic condition of London traffic of all kinds. I am strongly of opinion that cab, motor omnibus, indeed every kind of vehicular traffic, including underground railways and tramways should come within the purview of the proposed tribunal.

One of the greatest benefits conferred by a special body of the kind would be that all projects could be dealt with so exhaustively as to obviate any subsequent opposition by interested parties.

Assuming the recommendations contained in the Royal Commission's Report to be such as will lay the foundations for a comprehensive and unified system of metropolitan communication, some three or four years may elapse before Parliamentary confirmation can be obtained and the new body set to work, and while matters are taking practical shape, London cannot stand still. In spite of the fact that many projects have been set back for consideration after the issue of the Traffic Commission Report, important developments continue. Hence the sooner we arrive at an authoritative solution of the general problem, the better it will be for all concerned, and it is very important, I would venture to suggest, that Parliament should thoroughly recognise the necessity for some definite pronouncement on the conclusions of the Royal Commission at the earliest possible moment after the publication of the forthcoming report.

Although more particularly identified with the development of electric tramways, I fully recognise the valuable assistance afforded by shallow and low level underground electric railways, especially if worked in conjunction with surface lines.

To realise the importance of this point, it is only necessary to refer to a map of the metropolis showing the various completed and authorised suburban routes of the London United Electric Tramways. From Uxbridge in the north-west, we have a line providing intercommunication between towns and villages, and serving as a feeder to the Central London Railway at Shepherd's Bush, and the District Railway at Hammersmith and elsewhere. Again, from Staines in the south-west, is another route intended to perform similar duties and bringing passengers from a network of branch tramway lines to the Central London and District Railways at Hammersmith and other stations on the latter system. Further to the south, the existing lines, and lines under construction or authorised, provide services between London and numerous important suburbs, provide for feeding numerous railways, and for through communication with the existing tramway system of the London County Council.

The London United Electric Tramways have already formulated a complete programme offering such fares and arrangements for through traffic as would entirely gratify and, as I believe, satisfy the people of London. Thus, starting from the extreme western and south-western termini of the London United Electric Tramways and joining, at Hammersmith, the Metropolitan District Railway now being electrified, the

combination would offer through fares and through bookings over both systems. Powers were sought in the Session of 1904 to give access by a specially designed electric subway so that tramway carriages might proceed direct from the surface to the level of the railway station platform, therefore affording immediate and convenient (under cover) facilities for change of carriage. It was proposed that from Hammersmith the electric trains on the District Railway should make direct connection with the various tube railways now nearing completion, namely, the Baker Street and Waterloo, the Charing Cross, Euston, and Hampstead, and the Great Northern, Piccadilly, and Brompton lines.

This combination of surface tramways, the electrified district, and the tube railways, would furnish an object lesson of what ought to be done elsewhere in the metropolis, and would constitute a long step towards the desirable consummation of exchange stations, frequent services and through bookings at cheap fares.

Interchange of Traffic.—This question between different tramway authorities is one that is not absolutely urgent for the moment, but will become of very considerable importance later on. Facilities of the kind are common in the United States, where the tramway traveller has the same advantage as the traveller by railway in securing "through tickets" and "through carriages" with no need to trouble himself when he passes from one system to another.

In this connection I may mention that the completion of the Surrey extensions of the London United Electric Tramways will provide a complete system of suburban lines between Hampton Court, Surbiton, Kingston, Wimbledon and Tooting. Notwithstanding the different applications of electric traction used by the London United and the London County Council tramways respectively, nothing could be easier than to provide for the exchange of cars between the two systems. The collecting shoe could in transit be dropped into the conduit, while the overhead trolley pole could be adjusted to or from the overhead wires as occasion demanded.

The successful development of electric tramways over the enormous area on the western boundaries of London, in spite of the opposition and rapacity of local authorities, has demonstrated, in an incontrovertible manner, the immense capabilities of the tramway system for relieving congestion of traffic, and for conveying myriads of workers to and from the business centre with speed and comfort.

Motor Omnibus v. *Electric Tramway.*—This subject has been discussed a good deal of late in the Daily Press and elsewhere. As an automobilist of several years' experience, I fully appreciate the great advantage of motor vehicles for many purposes, but the personal knowledge which has proved their good points also indicates their limitations, and especially in the line of dealing with really large volumes of traffic satisfactorily, and at the low fares which are absolutely essential in the case of the metropolis.

In the city and other parts of London where tramways are at present prohibited, the motor omnibus will certainly prove a great boon, and that it will ultimately supplant that glaring anachronism—the horse bus—is beyond question. In isolated districts unprovided with tramways, the motor omnibus will also be found of service, and it is possible that this type of vehicle may be adopted with advantage where population is insufficient to justify the installation of an electric tramway system.

But to-day the motor omnibus cannot be accepted as a commercial success. It is at present liable to break-down, explosion, and fire, being dangerous to life and property, and evolving a particularly malodorous atmosphere wherever it goes.

I do not say that the motor omnibus has no future, and representing important tramway interests in various parts of Great Britain, I fully realise the possibility that the time may come when makers will produce a really efficient

mechanically-propelled omnibus which may prove useful as an auxiliary to the electric tramway.

The period covered by the existing ventures in the way of motor omnibus services is insufficient to justify—with any chance of finality—the results likely to accrue in practice even under favourable conditions, and owing to the sporadic nature of their operations in the metropolis it is difficult to obtain any actual figures relative to running costs. This was amply borne out in the evidence recently given before the Royal Commission by the Manager of the Road Car Company. This company has been running motor omnibuses for some time, and when he was asked if he could give the Commission any figures as regards cost, he said "I could give you figures, but at present we are not quite sure how far those figures will be verified in the future. As regards running costs, he said "I should not like to commit myself to any figure." After finally suggesting that probably 7*d*. to 10*d*. per mile would be the cost as nearly as possible, he said "We feel we have not had sufficient experience to bind ourselves to figures." On a member of the Commission suggesting that he could surely supply the actual running cost for the time their motor omnibus had been on the road, he said, "Yes, but we think it would be unwise to give that figure for the reason that we think it will be larger in future. Our motors are new and very few renewals have been necessary." However, taking the figures generally accepted as applicable to the exceptionally favourable conditions afforded by the streets of London, a comparison with existing electric tramways is distinctly interesting.

The London United Electric cars accommodate seventy passengers, and taking the fare at one-halfpenny a mile, the earning capacity is 2*s*. 11*d*. per car mile. Taking the maximum carrying capacity of a motor omnibus at thirty-two passengers at a similar rate of fare, we have a maximum earning capacity of 1*s*. 4*d*. per bus mile.

The annual revenue per electric car-mile run averages 10*d*., as against a total expenditure of 6*d*., and during 1904 fully fifty million passengers were accommodated at fares averaging less than a half-penny a mile and half that sum for the working classes, the lines being kept in full operation all the year round for twenty hours a day.

In the figures published relative to the operation of motor omnibuses in London, the average revenue has been stated at 12·52*d*. per mile run, and the working expenses at 10·52*d*. It is not stated whether the working expenses include repairs and maintenance, and until the return issued recently by the Corporation of the Borough of Eastbourne, it was most difficult to obtain reliable data as to the real commercial value of motor omnibus operations.

From this return it appears that the results of a second year's working of their motor omnibus service give the following striking results: Total cost per 'bus mile, 10·67*d*.; gross income per 'bus mile, 10·38*d*.; nett loss per 'bus mile, 0·29*d*. As a result of this unfortunate state of affairs, I have seen it stated in the Press that the town council have decided to convert their motor omnibuses into water vans and dust carts.

One claim frequently made is that the motor omnibus has a favourable chance of succeeding, because no capital has to be sunk in permanent way construction and in the erection and equipment of power stations. As a set-off against this, we must remember that so long as rubber tyres are deemed essential to the efficient equipment of an omnibus, this claim is simply a delusion. Solid rubber tyres under the most favourable terms represent twopence per mile run for maintenance, and this heavy charge capitalised over a year's working would exceed the cost per mile of electric tramway construction, including power station, cars, and equipment. Further, there still remain all other repairs and maintenance of the petrol engine, to say nothing of the uncertainty of the supply and future cost of the oil. On the other

hand, the maintenance of tramway car wheels cost only ·05*d.* of a penny per mile run, and the total maintenance of an entire tramway undertaking on a large scale, works out at about 1·10*d.* per mile run.

It must also be remembered that double as many motor omnibuses would be required as tramcars, owing to the greater capacity of the latter. Now the first cost of two motor omnibuses is about £1,800, while that of a tramcar is only about £600. Therefore, without taking any other points into consideration, it will be seen that the shareholders of tramway companies can afford to regard the attempted boom of the motor omnibus with considerable equanimity.

From the mechanical point of view the motor omnibus is severely handicapped by the fact that it has to be propelled over ordinary roads. Even wood-paving and asphalte become lumpy under heavy traffic, while macadam and setts are notoriously uneven. Hence, even on level routes, the propulsive effort must necessarily be high in proportion to the size of the vehicle, and as the weight of the motor equipment must be taken into account as a part of the load, it is obvious that the power required for a motor omnibus must be far greater in proportion to its weight and carrying capacity than for an electric tramcar proceeding along smooth rails and picking up energy transmitted from a central source of supply. The question of friction strikes at the very root of the matter, and tramways will never be displaced unless some mode of traction can be found which represents greater economy of power than the motion of a smooth metal wheel over a smooth metal rail. No one can pretend that the motor omnibus offers any such improvement.

No uncertain and disconnected service, liable at any time to interruption or disconnection, will ever acquire or retain public confidence where heavy passenger traffic is concerned. This aspect of the matter directly affects that part of the great housing problem, towards the solution of which electric tramways have accomplished so much, for the public have learned to place the same confidence in the permanence of a properly organised tramway as in that of our great railways.

Summing up the case for electric traction, and referring in particular to the overhead trolley system, I may say that it is simple in construction, easy in maintenance, cheaper than any rival in capital cost, and more economical in working cost from day to day than any other method yet known. The system is most elastic and comprehensive, for it is capable of meeting the most severe pressure of traffic on demand, while it can be profitably extended so as to give access to sparsely inhabited suburbs where the cost of any other system of mechanical traction could not be faced. An extended experience embracing nearly the whole of Europe and the Continent of America, and a most careful inquiry into all inventions and proposals, convinces me that the overhead electric trolley system is to-day the only system for adoption wherever the question of street traction has to be considered on a commercial and scientific basis.

The Tram and Road Cars of the Future.*

By ALEXANDER CLERK, A.M.Inst.C.E.

THE question of the tramcar cannot be separated from that of the method of propulsion. In its early days it was horse-drawn, afterwards a locomotive took it in hand, when it required a covering on the top of the double-decker, to protect passengers from the smoke and soot. Later it was provided with electric motors, but it still required current from the power station to set them in action before the car could move. Now a higher state of development has been reached, when the car may be provided in itself with all that is necessary for motion.

As the system of electric traction, with wires or cables either overhead or underground, still holds the place of honour in large centres of population, we shall have some remarks to make later on with regard to the expense of working that system; but our object is, in the first place, to examine in detail the construction and development of a self-propelling and independent tramcar, and thereafter shortly to describe the road car.

When we call the auto-tramcar the highest development of the present time, we would by no means seek to cast any doubt on the possibility of still further improvements in the future, which may completely overshadow anything we may now have in our minds. For the same reason we deprecate the continual carrying out of electric systems of traction after it has been shown that a much better solution of the question is ready to hand. More especially is it inadvisable to spend large sums of money meantime on electric traction, when the same object can be achieved for one half of the expense by the auto-tramcar.

Car Body.—The portion of the car which first appeals to the public is the accommodation for the passengers, and the general finish of the outside and inside of the car body (see Figs. 1 and 2). In the new tramcar it is not proposed to interfere with the arrangements of the ordinary type of car. The ordinary type of car can be accepted and fitted up to suit the new engines and gearing. While, however, a change in form or arrangement is not a necessity, it is not admitted that the present arrangement is as ideal as it might be, and we submit a design for the inside seating, which would at least be a new and also a more agreeable arrangement (see Fig. 3). In the plan before us there is a variety of view which should make the car journey more interesting to the passengers, and presumably more pleasant. The seats on the upper deck are of the usual form, except the two end ones, which are curved, and made suitable to fill the two irregular spaces.

This car has seating accommodation for twenty passengers inside and thirty outside, or fifty passengers in all.

The two seats in the centre of the inside of the car are made movable, to afford access to the engines and gearing, and the floor can be made to lift if necessary.

The spaces under the stair at the conductor's end may be used for parcels, for which access is made from the private compartment.

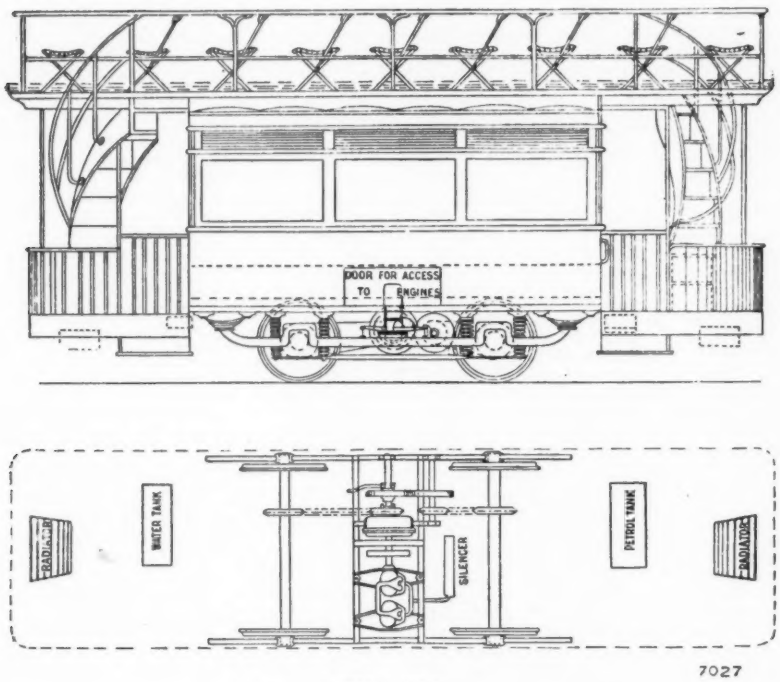
The petrol and water tanks and the silencer are disposed of under the car floor, so that they do not interfere in any way with the passengers, and the two radiators stand at each end of the car, either on the top or on the lower platform, as may be found most convenient.

In other respects the finishing of the car, both outside and inside, is after the usual method, and of the style which has been found most suitable from experience.

Bogie below Car.—The bogie under the car is specially constructed to carry the engines and gearing. It has four wheels 2 ft. 7½ in. diameter, with axles 3½ in. diameter, and outside journals 8 in. long by 3 in. diameter. It is provided with two spiral springs, carrying the main truck frame on the projecting ears at each journal box, or eight springs in all. These are the only springs under the engines and gearing, all the others being required for carrying the main body of the car in its position above the bogie.

As the springs of the car may be depressed or relieved, according as the number

* Abstract of a Paper read before the Royal Scottish Society of Arts.



FIGS. 1 AND 2.

of the passengers is increased or diminished, all the levers or rods which are attached to the body of the car, and require connection with the machinery on the bogie, must be so constructed that this change of relative position does not affect them. Thus, the rods from the controllers on the cars are connected with the rods on the bogie for operating the change gear speeds with universal joints.

It is most important to bear in mind this distinctive feature of the design, viz., that the engines are not connected with the body of the car, and consequently do not affect it with their vibration.

The Driving Wheels.—On each of the axles a sprocket chain wheel is fixed, and these are driven by chains from the pinions on the main axle and on the countershaft. Each of the axles is alternately in front as the direction of the car is altered, and it is always the leading axle to which the power is applied. When the car is driven directly from the main shaft, the spur wheel, which is mounted on a movable sleeve, engages the chain pinion, the leading axle being driven by the chain as above described. When the car has to be reversed this spur wheel is relieved from contact with the chain pinion on the main shaft, and set in gear with an equally sized wheel on the countershaft. A chain pinion equal in size and pitch to that on the main shaft is fixed on the countershaft, and from this chain pinion the motion is communicated to the other axle, which in this case is the front or leading axle. When the car is driven from the countershaft the main shaft runs free through the chain pinion first described, and it is only driven by means of the spur wheel when it has been engaged with the clutch. There is no possibility of any damage being done by means of the gearing becoming locked.

Speed-reducing Gear.—We have so far not dealt with the question of speed, but, as the revolutions of a petrol engine are greatly in excess of the number of revolutions of the car wheels, a method of reducing the speed is necessary to satisfy the conditions.

There are many ingenious inventions designed to meet the circumstances. The device which is used in this car is that of an epicyclical gearing in which a central pinion works into toothed wheels and causes them to revolve, whilst on the outside the teeth of the revolving wheels engage with the teeth on the inside of an outer rim which surrounds the whole system. If the axles of the two second motion wheels be fixed the motion from the central pinion will be communicated to the outer rim, and it will move in the opposite direction from the pinion; but if, on the other hand, the rim of the outer wheel be held by a brake band, or similar contrivance, the two intermediate wheels will move around the centre pinion instead of causing the outer rim to move. If, then, the axles of the two moving wheels be connected rigidly by a plate or a casting which forms part of a sleeve on the axle, the speed will be reduced in the proportion of the respective diameters of the outer rim and the centre pinion.

A reverse motion is also provided in a very simple way. The axles of the two revolving wheels are produced and two pinions are fixed upon them—those in their turn are constructed to work into two other revolving wheels moving in a plane just outside of those before referred to, and thus the reverse motion is accomplished.

The perfect balance of this gearing and the want of shock in changing from one speed to the other, are the most noticeable features in connection with its use, and it has been specially adapted for use in this car. The shaft giving the different changes of speed is arranged so as to work from either end of the car, a clutch being placed in the controller at each end of the platform so that the gear can only be operated from the driver's end.

The full speed of the car is put at 15 miles per hour. There are also two lower speeds of 6 and 9 miles per hour, the lowest speed only being used for starting or working an exceptionally heavy gradient.

Engines.—The engines are of the four-cylinder "Otto" cycle type, with cylinders $4\frac{1}{2}$ in. diameter and $5\frac{1}{2}$ in. stroke, capable of giving continuous power, under working conditions at 1,000 revolutions per minute, of 30 h.-p. with petrol fuel.

The valves are all mechanically operated, and the full speed and power of the engines can be taken up by the gearing either in mounting a steep gradient at the speed of 6 or 9 miles per hour, or by taking the full speed of 15 miles per hour along an easy level track.

The speed of the reverse is 6 miles per hour, to be used only in cases of emergency.

The cubic contents of the working part of each cylinder would be 87·4736 cubic ins.; the compression chamber usually about one-sixth or 14·5789 cubic ins.; making a total volume of 102·0525 cubic ins.

The proportion of the mixture in the cylinder, if just enough of air has been drawn in to make a perfect explosive mixture, would be $C_7\ H_{16}\ 11\ (O_2)\ 41{\cdot}4\ (N_2)$.

At 1,000 revolutions per minute 1 gallon of petrol would run for twenty-five minutes.

At 6 miles per hour:—2·50 miles per gallon of petrol.

At 9 miles per hour:—3·75 miles per gallon of petrol.

At 15 miles per hour:—6·25 miles per gallon of petrol.

From this calculation it would appear that if a journey of 40 miles could be done continuously at the rate of 15 miles per hour, the petrol required would be 6·4 gallons, whereas if an average of only 9 miles could be kept up, an amount of 10·66 gallons would be required.

It is important to observe, however, that in a road of 40 miles there would probably be many parts level and downhill, besides some portions with very easy rising gradients

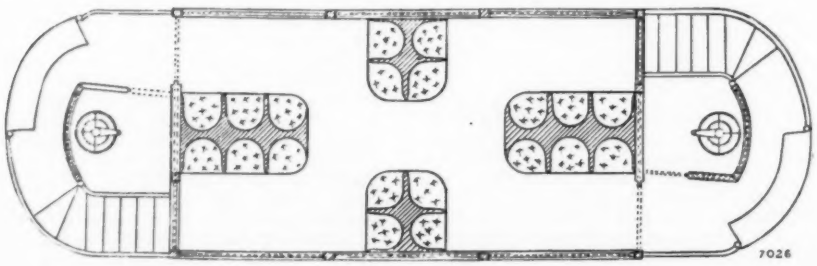


FIG. 3.

where the full explosive stroke would not be required, and on all these lessened strokes a considerable saving of fuel would be effected. This theoretical calculation would therefore be modified to a large extent by taking all the gradients and calculating for each separate value.

Tanks.—A water tank to contain about 3 cubic feet, or say, about 20 gallons, would be sufficient to supply water for cooling purposes, and a petrol tank to carry about 12 gallons would supply the necessary fuel for a journey of 100 miles. It was shown by calculation that a gallon of petrol would run about 6·25 miles at full power and speed, but, as a rule, fully one-half would be easy work, either on the level or down hill, when very little fuel would be required. In these cases the exhaust can be left open so that the compression stroke will not act as a brake on the motion of the car, also the petrol supply can be cut down to a limit of about $\frac{1}{32}$nd part of the full stroke. An average of a gallon per 8 miles will therefore be amply sufficient.

Resistance, Tractive Force and Adhesion.—The total weight of a tramcar built as described would be nearly $4\frac{1}{2}$ tons. Add for weight of load $3\frac{1}{2}$ tons. Representing a total load of 8 tons.

The resistance of this on the level at 15 miles per hour (V) would be

$$R = 6 \cdot 009V^2.$$
$$= 6 \cdot 009 \times 15 \times 15 = 8 \cdot 025 \text{ lbs. per ton.}$$

Add to this for extreme gradient 1 in 16. $\frac{2{,}240 \text{ lbs.}}{16 \text{ lbs.}}$ or 140 lbs. per ton.

Therefore:—

Total tractive force per ton = 8·025 × 140 lbs.

Total tractive force per ton = 148·025 lbs.

Total tractive force for loaded car (8 tons) = 148·025 lbs. × 8.

Total tractive force for loaded car (8 tons) = 1184·2 lbs.

The pressure on the engine piston is over 200 lbs. per square inch upon a piston of 15·9 square inches, and we also have a gearing of 1 in 6 ratio at full speed. If, then, we consider only half of this power developed, we would have 100 lbs. × 15·9 sq. in. × 6 = 9,540 lbs. of tractive force available to meet the 1,184 lbs. required to take the car up a gradient of 1 in 16 at the speed of 15 miles per hour. Further, we have the lower gearing of the ratios of 10·4 and 15·6 for 9 and 6 miles per hour, which are always available if required, and which would greatly increase the tractive force.

There still remains the question of adhesion. This is a varying quantity. With the rails in good condition 600 lbs. per ton could be reckoned on; but in ordinary British weather, which includes a good deal of all sorts, a more reliable figure would be 450 lbs. per ton, or 3,600 lbs. per car of 8 tons. Should matters come to the worst, the usual application of dried sand is available until something better is invented.

Petrol Car for 3 ft. 6 in. Gauge.—The observations made so far refer to the construction of a tramcar for a gauge of 4 ft. $8\frac{1}{2}$ in. When we come to the details of a car for a 3 ft. 6 in. gauge some alterations may be made, if considered necessary or advisable. This is merely a matter, however, of the adaptation of the existing engines and gearing for the work. If the arrangement already described for the wider gauge be preferred, there is no difficulty in adapting it also to the narrower gauge, but an alternative system may be briefly described, which may find favour in the eyes of some under certain conditions. The most important differences from the car just described are:—

(1) The engines are placed longitudinally and not transversely; they are also in the centre of the car instead of being under the side seats.

(2) The drive from the main shaft is still continuous, but being longitudinal it necessitates the intervention of a set of three bevel wheels in order to change the direction to that of the axles of the car.

(3) The two shafts of a pair of these bevel wheels, which are exactly in the middle of the car, and are driven from the central bevel wheel in opposite directions, carrying also two chain pinions which are fixed exactly opposite two chain wheels mounted on the axles of the car. The two axles of the car are thus driven alternately from the chain pinions according as they are connected by the respective clutches to the cross shafts before described.

(4) The arrangement of the seating in the interior of the car is also altered, owing to the change in the position of the engines. In this case there are four single seats which take the form of chairs, and one central seat of double width on which there is accommodation for sixteen passengers eight on each side). This arrangement provides for twenty passengers inside. The outside arrangement is for thirty passengers, as in the case of the wider gauge car.

(5) Owing to this alteration in the inside seating the doors are placed in the centre

as usual, and the stair to the top of the car turns to the right hand instead of the left. The passengers, therefore, all pass between the conductor's box and the car entrance.

(6) A portion of the end of the central seat is made portable for access to the engines, but there is also a considerable space under the car which may render the removal of any part of the seat seldom, if ever, necessary.

Steam Tramcar.— A steam tramcar can be produced in which the working machinery is disposed so as not to affect the main portions of the vehicle as we now know it, to any appreciable extent (see Fig. 4). To follow out similar power and dimensions to that which we have been considering: the boiler would be placed under one of the stairs, and, as all its operations are automatic, it would require no attention beyond the first raising of steam and the setting of the automatic regulators. It (the boiler) consists of a cylindrical shell of steel plates about 1 ft. 8 in. diameter and 1 ft. 8 in. high, having about 512 fire tubes $\frac{5}{16}$ in. diameter placed vertically, and developing a working pressure of 250 lbs. per square inch. The fuel used is ordinary paraffin oil, which is vapourised by passing through heated tubes, and burned in a specially constructed burner. It is automatically regulated by the steam in the boiler, so that if the pressure exceeds 250 lbs. to 300 lbs. the supply of paraffin is curtailed, and the flame lowered. There is an arrangement also for superheating the steam, The water is used many times over as it is condensed in a cooling coil or in the radiator, and pumped back again to the supply tank to be re-used again for feeding the boiler. Sometimes it is preferable not to pass the steam from the exhaust directly back again for use in the boiler, as, for instance, in climbing a steep hill, or in certain cases where the steam has to be economised. In these instances the condensed steam is, for the time being, pumped into a separate tank to be re-used again at a more suitable time for the boiler. This economy of steam gives the engines a considerable reserve of power when it comes to any situation where their full strength has to be put forth.

The boilers are tested to a hydraulic pressure of 700 lbs. per square inch before being used.

Engines.—The engine constructed to work the steam carriage with the boiler described has two cylinders 4 in. diameter × 4 in. stroke, and the main cranks make 277·2 revolutions per minute in developing a speed on the road of fourteen miles per hour, the driving wheels being 2 ft. 10 in. diameter, and the gearing between the main cranks and the driving axle being 1 : $1\frac{1}{2}$. If allowance be made for a $\frac{1}{3}$th cut-off stroke, which reduces the average pressure in the cylinders to 150 lbs., and also for loss and the proportion of time working when the full boiler pressure is not developed, the average pressure would be, say, 100 lbs. per square inch, and the piston speed—

277·2 rev. per min. × $\frac{4}{12}$ ft. stroke × 2 = 184·8 ft. per min.

Area of each cylinder 12·5664 sq. ins.

Total pressure on each piston = 100 × 12·5664 = 1256·64 lbs.

$$\frac{1{,}256{\cdot}64 \text{ lbs.} \times 184{\cdot}8 \times 2}{33{,}000.} = 14{\cdot}062 \text{ H.P.}$$

This is nominally a 12 horse-power engine, and it has abundance of reserve to work far beyond this power. We have not noted the additional gain from the gearing which would increase the power by one-half

Pumps.—There are four pumps used:—(1) To supply the feed water to the boiler from the main tanks; (2) to supply the paraffin oil for the burner into the oil pressure tank; (3) to circulate the lubricating oil to all the bearings; (4) pump for continuing the circulation of the water from the condenser back again to the main supply tanks.

Tanks.—The supply of water for a steam-engine is sometimes looked upon as a real difficulty to be reckoned with. In the case of this engine it is a very small matter indeed. If the engine be not condensing, about $1\frac{1}{2}$ gallons or 15 lbs. of water per mile has been used, but the condensing plant has been so satisfactory, that a tank of 34 gallons is found sufficient for 100 miles of an average road.

The paraffin used has worked out to about $\frac{1}{4}$th of a gallon per car mile, so

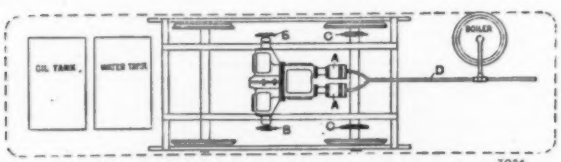


FIG. 4.

that a tank of 17 gallons would be a sufficient supply for a run of 100 miles. At the very worst parts of the road ¼ gallon per mile was enough.

There are many other ingenious points in connection with this new development of the steam tramcar which, did time permit, would form interesting topics, but these we have already pointed out will show how completely the whole mechanism has been designed. In fact, the details have been so successfully worked out that they can be applied at any moment in the construction of a tramcar as soon as the car is required.

The New Service Road Car of the Future.—We have still a few remarks to make on the New Public Service Road Cars. Although these have been at work for some time in certain districts, they have not yet come to be recognised or appreciated at their proper value. They have taken several different forms, according as they are required to act as the city tramcar, the 'bus to convey passengers to or from the railway stations (when they are expected to carry luggage), or the mail coach travelling through the country with the triple responsibility of carrying the mails, including the parcel post, the passengers, and their luggage. That there are many districts where the motor car in some of its forms can be put to some of these uses need not be demonstrated. In many parts of London, for instance, the traffic is so congested that, although conveyances are much required, it is impossible to lay down rails in the streets or to run tramcars on them. In these cases the motor car has taken the form of the old London horse 'bus with or without the top seats. Besides congested places, such as London, there are these places where with a few miles of road between two small towns, it would not pay to lay down tramway rails, and in such places the motor road 'bus is the best solution of the problem.

In comparing a motor tramcar with a motor road car, it has to be borne in mind that the traction on rails is approximately in the ratio of one on rails to ten or twelve on macadamised roads. According to this value, we should only require a pull of about 10 lbs. to draw a weight on rails equal to that which on a road requires a pull of from 100 to 120 lbs. We never, however, seem to get the full benefit of this ratio in tramway work. A tramcar weighing about eight tons loaded will require about a 12-H.P. engine. An engine of the same power will be considered ample for a road car weighing 40 to 45 cwts. loaded. The tramcar will accommodate fifty passengers, the road car will take sixteen passengers. The tramcar will be four times the weight, and the passengers three times the number. So far, then, the advantage is with the tramcar, which carries three times the number of passengers for the same horse-power of engine. But the expense of providing and laying the tramway must be paid for out of this saving, also the line must be kept up and the depreciation paid for.

For the rest, the road car is at a disadvantage with regard to its wheel tyres, it has a more complicated gearing to keep up, and beside being more flexible in itself it has a rougher road to travel on and is more liable to sudden jars, and also to collisions.

Further, the smaller-sized road car has not the capacity to take a large extra number of passengers at the busy times of the day, while the more capacious tramcar may make up a decent average for the day by getting its space fully filled up at the special times when passengers are most plentiful. The average number of passengers conveyed by the larger car may be much less than the capacity of the smaller car, but the latter car never recovers the loss from the small averages of the less busy seasons. No doubt the car runs more easily and lightly during these slack seasons, and the heavier car has a greater weight to carry per passenger at all times, but especially when the proportions of passengers are at the lowest ebb.

We pass on now to the comparison of the cost of working and construction with the systems now in use.

It will, no doubt, be admitted almost at the beginning that if we have succeeded in showing that a tramcar can be constructed and run, such as has been described, it will be more economical both in construction and working than any other system which meantime holds the field.

If we analyse the costs of some of the electrical systems on the table on p. 84 we shall be able to see what are the elements which combine to make up the outlays, the revenue, and the cost of working.

Taking the town of Nottingham as an example, we have thirty miles of single tramway, costing £558,838, or an average of £18,661 per mile. But this does not include the expense of the electric station, and as one-half of the whole electric power of the station is consumed in working the tramways, it is only fair that this proportion of the cost of the station should be added to the capital spent on tramways. This half comes to £200,000, which being added to the cost of the thirty miles of tramway is

TABLE OF COSTS OF ELECTRIC TRAMWAYS.

	Route Miles.	Capital Total.	Capital per Mile.	Receipts.	Expenses.	Interest, etc.	Renewals and Depreciation.		Relief of Rates.
							Total.	Per Cent. on Capital	
		£	£	£	£	£	£		
Aberdeen	12	324,597	27,050	50,986	26,381	7,667	16,938	5·47	
Dundee	12·3	309,634	25,174	42,005	27,126	8,446	6,433	2·08	
Dover	3·5	65,450	18,700	11,636	8,479	1,184	1,973	3·00	£
Glasgow	65·25	2,372,789	36,365	656,572	304,315	66,131	261,126	11·00	25,000
Liverpool	71·22	2,363,485	33,185	544,720	341,463	53,454	117,722	4·98	32,081
Nottingham	17·0	758,838	44,637	128,202	71,259	15,333	28,610	3·77	13,000
PROPOSED NEW MOTOR TRAMWAY.									
Double Track	5	95,000	19,000	32,120	18,980	3,325	9,815	10·33	

equal to a mileage addition of £6,667 per mile, making the total cost £25,328 per mile.

		Per car mile.
For the year ending 31st March, 1904, the receipts from traffic amounted to	£128,202	or 12·25*d.*
Expenses... ...	£71,259	
Interest	15,333	
	86,592	
Leaving for Renewals and Sinking Fund	£41,610	
There is no exact amount given of what the renewals cost, but it may be taken at the amount reserved for the year, which is	13,482	
	£28,128	
Out of this a sum was devoted to the relief of rates amounting to ...	£13,000	
Leaving for Sinking Fund	£15,128	

The question comes to be—what percentage should be allowed for depreciation? Considering that the greater part of this expenditure is for machinery and rolling stock, or its equivalent, an allowance of 5 per cent. per annum is not too large an amount.

Depreciation at 5 per cent. on capital	£37,941
So that the Sinking Fund of	15,128
Leaves a loss in value of	£22,813

and there was really no money over to apply to the relief of rates although £13,000 was actually paid. The amount actually set aside for Sinking Fund was a little under 2 per cent.

Dover Tramways.—If we examine similarly the returns of the accounts of Dover for the year ending 31st March, 1903, it runs thus:—

Expenditure on Permanent Way Plant, &c.	£39,450
One-fourth of Generating Station ...	26,000
TOTAL Capital	£65,450

Being for 3½ miles of route:—£18,700 per mile.

		Per car mile.
	Receipts £11,636	= 10·23*d.*
Expenses	£8,479	= 7·45*d.*
Interest	1,184	
Sinking Fund and unappropriated Balance	1,973	
	£11,636	

The depreciation on £65,450 being the total amount of Capital	£3,272
But Sinking Fund and Balance only ...	1,973
There is, therefore, a deficiency of ...	£1,299

besides the fact that nothing is put down as charged for renewals.

	Per cent.
The amount of Sinking Fund being only	1·45
And the unappropriated Balance ...	1·55
TOTAL...	3·00

Dundee Tramways.

	15th May, 1903.
Capital Expenditure	... £256,634
Power Installation (one-third)	... 53,000
	£309,634

Being £25,174 per mile.

		Per car mile.
Receipts for year ...	... £42,005	or 11·09*d.*
Expenses ...	£27,126	
Interest ...	... 6,246	
Accident and paid Company ...	... 2,200	
Sinking Fund and Depreciation ...	... 6,433	
	42,005	

The depreciation at 5 per cent. on Capital ...	... £15,482
But the Sinking Fund, &c., only	6,433
Being deficiency of	£9.049

The depreciation fund in this case is only 2.08 per cent.

Aberdeen Tramways.

	To 15th May, 1903.
Capital Expenditure	... £259,597
Power Installation (one-third)	... 65,000
	£324.597

Being £27,050 per mile.

		Per car mile.
Receipts for year ...	... £50,986	or 12·66*d.*
Expenses ...	£26,381	6·55
Interest ...	... 7,667	
Sinking Fund and Depreciation ...	... 16,938	
	50,986	

The Depreciation at 5 per cent. on Capital ...	... £16,229
And the Sinking Fund &c. ...	16,938
Leaving a surplus of... ...	£709

The London County Council are proposing meantime to lay down tram lines on the Thames Embankment for a length of 1⅛ miles, at a cost of £146,600. If they are fortunate enough in earning 2*d.* per car mile, after paying all expenses, they will have to run a car every minute both ways on the track for every day in the year, and for sixteen hours a day, in order to pay 3 per cent. interest on the money, and 5 per cent. depreciation on the plant:—

5 per cent. + 3 per cent. = 8 per cent.
8 per cent. on £146,600 = £11,728 per annum.
= 2,814,720 pence.
365 days × 16 hours × 60 mins. × 3¼ miles =
1,138,800 miles.

$$\frac{2{,}814{,}720 \text{ pence}}{1{,}138{,}800 \text{ miles}} = 2{\cdot}56d.$$ profit per car mile.

Almost anything is possible in London in the way of traffic, but we contend that this extraordinary expense is unnecessary, and we wish to show that there is a method of doing the whole of the work in a simpler and easier way.

If we now take as an example an ordinary tramway with rails, say, 84 lbs. per yard laid with a double line, and all points, crossings, &c. required, and 5 miles long.

Say, 10 miles single track @ £6,000 or	£60,000
Add for car sheds and sundries ...	10,000
	£70,000
25 cars complete @ £1,000	25,000
CAPITAL	95,000

Car service every day 16 hours (5 minutes)
16 hours × 12 per hour × 10 miles = 1,920 miles daily.
1,920 miles daily × 365 days = 700,805 miles yearly.
Pay back £9,500 annually, being whole capital in ten years.

$$\frac{£9.500}{700{,}805} = 3{\cdot}250d.$$ per car mile.

Working Expenses—

		One car for one day.
Two drivers (eight hours each)	@ 6*s.*	£0 12 0
Two conductors ,,	@ 4*s.*	0 8 0
Fuel, 100 miles	@ 1½*d.*	0 12 6
Lubricating oil, 100 miles	@ ½*d.*	0 2 1
Cleaners, waste, &c.	...	0 7 0
Repairs and renewals	...	0 2 0
General expenses, office, &c....	...	0 10 0
		£2 13 7

$$\frac{£2\ 13\ 7 \text{ per day}}{100 \text{ miles.}} = 6{\cdot}43d.$$ say 6½*d.* per car mile.

Receipts may be estimated at 11*d.* per car mile.

	Per car mile.	Per day.	Per annum.
Abstract receipts ...	11*d.*	£88	£32,120
Expenses	6·50*d.*	52	18,980
	4½*d.*	36	13,140
Deduct Depreciation ...	3¼*d.*	26	9,490
	1¼*d.*	£10	£3,650
Interest on Capital 3½ per cent. ...	...	...	3,325
BALANCE	...	...	£325

If we compare the result of a similar double line 5 miles long constructed on the overhead electric system, the result will work out something like the following:—

10 miles of single track, including cars, car-sheds. generating stations, &c., at £18,000 per mile, or a total of £180,000.

If this amount were to be paid up under the same conditions as have already been calculated for the motor car tramway, the depreciation would be £18,000 per annum, and working this out for the same mileage

$$\frac{18{,}000}{700{,}805 \text{ miles}} = 6.16d. \text{ per car mile.}$$

This is a loss of about 3*d*. per car mile.

With regard to the ordinary working expenses it is evident that the cost of the men in the generating station will be all additional, and that extra men will be required on the permanent way to attend to the wires, both underground and overhead. This could not be estimated at less than 2*d*. per car mile.

Taking these two items of extra expense, we have a yearly loss on a 5 mile double route of:—

700,805 miles at 5*d*. or £14,600 2*s*. 1*d*.

To such towns or districts as have already embarked in tramway schemes and have laid down rails, the motor tramcar will come as an enormous saving; but to such places as have not yet so occupied the roads so as to interfere with the traffic, the motor road car must successfully appeal. After all that can be said in favour of tramways it must be admitted that they sadly interfere with the road traffic, and where it is possible to avoid this it is always most satisfactory to do so. The motor petrol or steam car can travel quite as fast as a tramcar, and as it is not confined to rails it may change its route at any time to suit public convenience.

The introduction or proposed introduction of the light railway has never been a success in this country, as in nearly all cases the cost of carrying it out has been about equal to the expense of a main line. In the suggestion we have endeavoured to give there is a considerable departure from established custom to meet the wants of the times and suit the public convenience by having a light railway in truth and reality. Very much lighter rails can be used, the large expense of stations will be virtually done away with, the transit and delivery of goods will be accomplished at a much cheaper rate and the convenience of the public will be served in many ways that the present system cannot accomplish in any satisfactory or rational manner.

The main trunk lines of railways would in many ways be greatly benefited by the intercommunication on the cross roads by systems of tramways and road cars, and when these are made to work conveniently together, hundreds of small towns and villages will be brought into such close contact that it will be possible to live at some distance from the towns and still attend to business every day.

But the electric tramway is in no way suited to meet the case. It is costly and cumbrous—whereas we now require something which is more flexible in itself and more capable of being adapted to the varying needs of the community. Such a system we have in the motor tramcars and the motor road cars. In themselves they are complete units not depending upon the working of machinery some miles distant. and the successful keeping up of communication with a central power. We therefore submit that this system claims the first consideration at the hands of municipal authorities or others engaged in projecting extended schemes of locomotion throughout the country.

Electric Tramways and Motor Vehicles.

By W. WORBY BEAUMONT, M.Inst.C.E., M.I.Mech.E., M.I.E.E.

TRAMWAYS and motor vehicles should be complementary, not necessarily antagonistic.

Tramways in any but broad streets and roads are obstructive where any quantity of other traffic exists.

Tramways in narrow streets where the traffic is heavy reduce the carrying capacity of the street by much more than the space the cars occupy and are a source of great danger to every other kind of vehicle.

Tramways are desirable where they can be laid in wide roads, more particularly where they can be run on the side of the roads or off the roads where the cars do not cause traffic inconvenience by their inability to accommodate themselves to other traffic by steerage.

Tramways of this kind are desirable at present where great numbers of passengers have to be carried at some parts of the day, where there is great traffic density.

Tramways should become railways when the traffic density is very great between two or more centres or sources of traffic—there are few existing common roads made or intended or proper for such traffic.

Motor vehicles cannot commercially perform the services of railway coaches on railways running and unrestricted on their own rails and own land.

Motor vehicles cannot commercially perform the services possible by a heavy system of eletrical tramways constructed under the Light Railways Act on wide suburban roads (*e.g.*, Shepherd's Bush, Acton Vale, &c.). These are to all intents and purposes railways and railway vehicles appropriating the best part of a public highway which, hereafter, will become too heavily crowded to permit the continuance of so rigid and space-occupying a type of vehicle.

Motor vehicles such as motor omnibuses will in the near future be able to deal with immense volumes of traffic, and will be able to accommodate themselves to a maximum variation throughout the day and week with an almost corresponding variation in the cost of working.

Motor vehicles being able to pass each other will be able to maintain a higher average speed than the tramcar with the same maximum speed as the tramcar, stoppage of one to put down or pick up not stopping one immediately behind.

Motor vehicles will in the near future have a total working cost less than that possible with the electric tramcar and tramway and their large establishment costs.

Motor vehicles run on bad roads now, but they require the good roads which are also required for every other kind of vehicle, and will be a great boon when we get them.

Tramways on common roads have only one reason for their existence, that is the lesser tractive resistance on them as compared with that on ordinary roads.

Tramways are a good excuse for bad roads and bad road making and maintenance, but with the great growth of traffic of all kinds on all our roads better road maintenance will become a popular necessity and popular demand.

Motor vehicles may be used as feeders to and distributors from railways and such tramways as are in use and are not intolerably obstructive to other traffic.

Motor omnibuses will in the near future supply the requirements of all proper street and ordinary high road passenger traffic; and the tramways and very heavy tramcars, which in some places are at present accommodating an enormous and growing business-passenger traffic volume, and converting certain places on these highways into monster badly managed railway sorting and collecting yards and sidings, will have to be treated as railways either overhead, underground or otherwise diverted from the streets and roads and provided with proper stations, to do the work of what they are—railways.

Recent Improvements in Motor Vehicles and Equipment.

Improved Motor Wagon Boiler.

THE motor wagon boiler illustrated in Figs. 3 and 4 is one possessing several features of interest, and for which the makers, Messrs. E. S. Hindley & Sons, Bourton, Dorset, were awarded a certificate of conspicuous merit at the Automobile Show held earlier in the year at the Agricultural Hall. The features of the boiler will be better understood by pointing out the difficulties attaching to the use of the ordinary vertical fire tube type and the ordinary locomotive type for motor vehicle work. In the case of the vertical fire tube boiler the tubes extend into the steam space, and not being surrounded by water at this point are liable to leak, especially during heavy work, when they become excessively heated. Further, the tubes stand vertically, close together on a horizontal surface, upon which solid deposits take place, which, in a very short time, choke up the spaces between the tubes, and it becomes impossible to remove this mud and lime deposit. As a consequence, the lower ends of the tubes may leak, and the crown plate of the firebox becomes burnt. This renders it necessary to disconnect the boiler periodically at two bolted joints, a laborious and costly performance generally beyond the skill of the ordinary driver. This adds greatly to the cost of working. Lastly, this type of boiler burns more fuel per ton mile than the locomotive type.

Difficulties arise in the application of the ordinary locomotive type boiler to motor road vehicles in cases where hilly roads have to be negotiated. Here the greatest caution becomes necessary by reason of the boiler being inclined while the water remains horizontal, thus running the risk of burnt plates or tubes which become uncovered by water. (Figs. 1 and 2).

In the boiler under notice there is no risk of this kind even when ascending or descending the steepest hill, and no more care is necessary than when on the level. This is indicated in Figs. 3 and 4, where each end of the inclined lines only rise and fall by a very small proportion. Again, the firebox of the ordinary locomotive boiler is generally a weak point in its construction, and is the place where difficulties first arise. The small size of the motor wagon boilers, the degree to which they are forced when in hard work, the use of fuel producing an intense local heat, all tend to try the firebox, and the presence of vertical seams and screwed stays is objectionable. The stays become coated with deposit, and are liable to leak on the firebox side unnoticed, and the firebox plates are very liable to crack between the stays. The intense heat produced by coke or smokeless coal acts on the double thickness of the lap joints in the vertical seams and sometimes causes leakage.

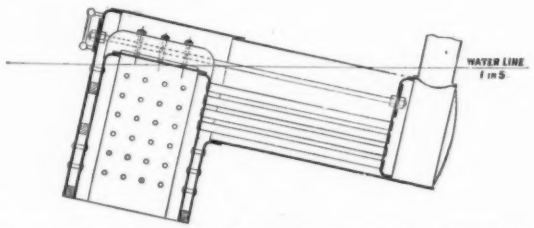


FIG. 1.—ORDINARY LOCOMOTIVE TYPE BOILER. DESCENDING A HILL; FIRE-BOX UNCOVERED.

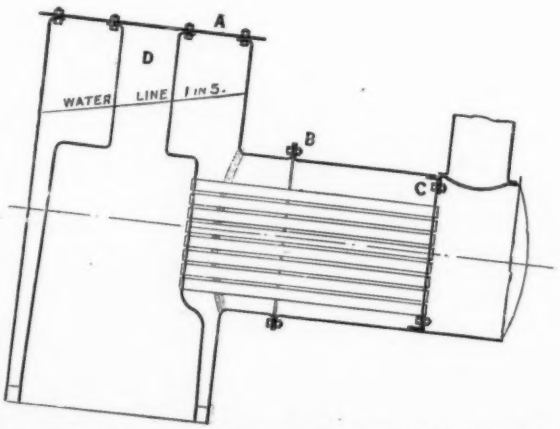


FIG. 3.—HINDLEYS' PATENT LOCOMOTIVE BOILER. DESCENDING A HILL FIRE-BOX WELL COVERED.

In the Hindley boiler there are no stays, and no vertical seams or double thicknesses in the firebox. Further, there is no fire-door, with its liability to crack, no bridge stays and no longitudinal stays.

It would appear to be a good steamer, and its natural construction provides a steam dome which tends to the production of dry steam, and obviates priming.

The downtake for feeding in the fuel satisfactorily stays the crown of the firebox to the removable cover.

The bolted joints can be disconnected for an entire opening up of the boiler, but this, we are informed, with ordinary water, is not necessary for twelve months, and even then the removal of the cover is all that is necessary. When this is removed the firebox, crown, and sides can be thoroughly scraped. It will be noticed also that all the tubes of the boiler are below the crown of the firebox, which carries the fusible plug, hence the plug fuses before the ubes get uncovered.

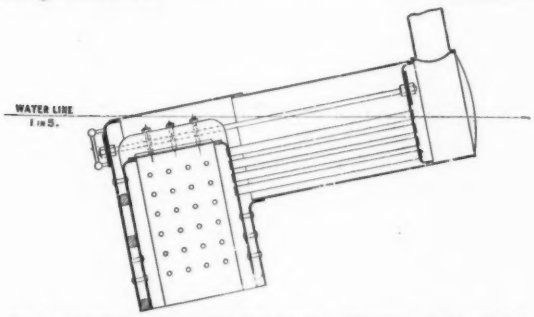


FIG. 2.—ORDINARY LOCOMOTIVE TYPE BOILER. ASCENDING A HILL; TUBES UNCOVERED.

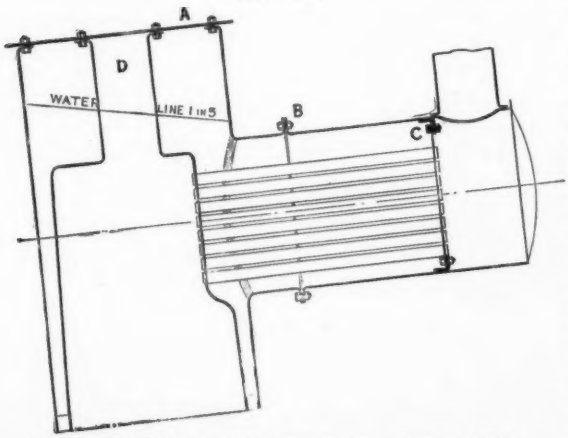


FIG. 4.—HINDLEYS' PATENT LOCOMOTIVE BOILER. ASCENDING A HILL ALL TUBES WELL COVERED.

Industrial Vehicles.

THE 4-ton steam lorry manufactured by the Thames Engineering Works, Greenwich, S.E., has some novel points in construction which make it differ considerably from other steam-propelled vehicles, the arrangement being adopted to ensure easy access to all the working parts both of the engine and the gears. For this purpose the engine is placed across the frame on the underside, and the power is transmitted to the road wheels through a bevel drive. The engine is a 2-cylinder compound horizontal, having cylinders $3\frac{3}{4}$ in. and $6\frac{1}{2}$ in. diameter and a 6in. stroke. It is fitted with flat balanced slide valves, the reversing gear being of the ordinary Stephenson link type, all parts being case hardened. The whole of the motion is enclosed in an oil-tight and dust-proof chamber, so that the engine requires a minimum of attention. A 2-speed change gear is provided, the change being made from the road, and the transmission is through a single universal joint and bevel gear, differential gear being placed inside the large bevel wheel. Both the change gear and the main drive are enclosed and worked in an oil bath. In practice this arrangement had been found quite satisfactory, and as all the gears are machine cut, the lorry runs with a notable absence of vibration and noise. The boiler is of the locomotive type, arranged with the fire door at the side, so that one man can attend to the firing as well as to the other operations required in driving. The boiler tubes are fitted with retarders, an arrangement which has been found to be most economical, the coal consumption working out at something like ·521 lbs. per gross ton mile. Particular care has been taken in the suspension of the waggon, the front springs being carried at the rear end on sliding brackets, while the forward end is connected with a cross bar which is pivoted at its centre to a bracket firmly secured to the front member of the frame. This provides a compensating action whereby the lorry can travel over the heaviest roads without racking the machinery. The springs of the back axle have sliders at each end, and the position of the axle is maintained by strong radial stays attached to the bearings. The arrangements for handling the lorry have been so far simplified

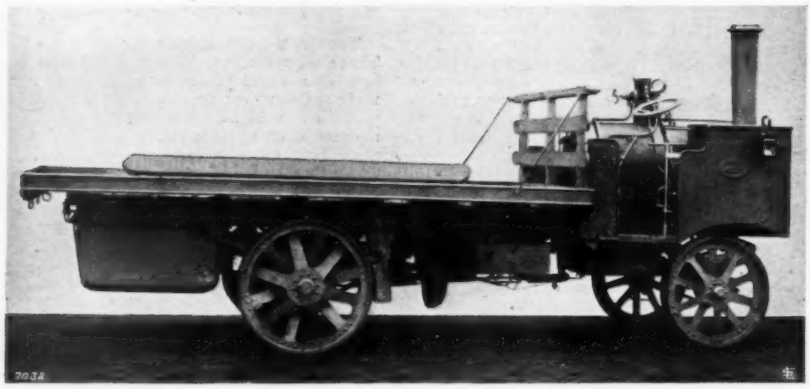


FIG. 5.—4-TON STEAM LORRY BY THE THAMES ENGINEERING WORKS.

that one man can easily attend to the operations of driving, and has under his immediate control the feed water and firing. The locomotive boiler proves so far economical that one good firing will run the lorry for four or five miles. The bunker capacity and water storage are sufficient for a journey of twenty-five miles without replenishing.

The Thames Engineering Works have also taken up the manufacture of petrol delivery vans, and Fig. 6 shows a very fine example of this class of vehicle. The machinery for this follows the usual lines, and consists—for the 20—25 cwt. van shown—of a 2-cylinder petrol engine with high tension electric ignition, a 3-speed change gear designed for giving speeds of four, eight, and twelve miles per hour. On the top speed the drive to the countershaft is direct through the bevel intermediate gear, with which is also incorporated the differential gear, there is a chain drive to the rear wheels. The lowest speed is arranged so that the van can take its maximum load up the worst gradients; the driving gear and seat are brought well forward so as to leave the maximum room for the van body.

THE liquid-fuel steam-driven vehicle, illustrated in Fig. 7, is that constructed by Messrs. Robert Morton & Sons, Ltd., Wishaw, under license from the Liquid Fuel Engineering Company. The special feature of this vehicle—which has proved very satisfactory, and by which the cost of running has been reduced to a minimum—is Morton's patent burner using crude oil. The engine is of the compound type, all the working parts running in oil-proof casings. The generator is of the "Lifu" pattern, and has a patent arrangement of copper pipes enclosed in a phosphor bronze casing and a steel drum. The employment of copper and phosphor bronze obviates the fitting common to the use of iron or steel tubes, the result being a boiler capable of resisting hard firing without subsequent trouble. The vehicle is steered with an ordinary lever gear but a steering wheel gear can be substituted if so desired. What is considered to be a most important improvement is the absence of chains and change gear, the engine being geared direct to the driving wheels. This engine and boiler is being built and fitted by Messrs. Morton to vans, lorries, and omnibuses with excellent results.

A COMMERCIAL vehicle useful for the rapid transport of light loads forms one of the specialties of the Albion Motor Car Co., Ltd., of Scotstoun, Glasgow, is shown at Fig. 8. It is made in various lengths of chassis to suit any desired type of body fitted with a 16 h.-p. motor, which is the standard type made by the firm. It is of the vertical double cylinder type, having cylinders 4¼ in. bore by 5 in. stroke, governed on the inlet by the Murray patent governor, which automatically regulates the speed, mixture and ignition advance, and is controlled by a single lever. The power is transmitted from the engine to the gear case through a spring drive, whereby the torque or driving strain from the engine passes through a set of springs which absorbs any jerks or shocks due either to uneven roads or to careless manipulation of the friction clutch.

The change gear provides three speeds forward and a reverse, the two higher being operated by positive clutches. The wheels for these always run in mesh, the top speed being a direct drive from the engine to the bevel gear.

The frame is of channel steel, the side

members being continued right forward to carry the front springs. All four wheels are 34 in. diameter, are of artillery pattern shod with solid rubber tyres.

FIG. 6.—PETROL DELIVERY VAN BY THE THAMES ENGINEERING CO.

A SIMPLE wagon, well within the tare limit and strong in construction, is that made by the Glasgow Motor Lorry Co., Limited. It is illustrated in plan and elevation in Figs. 9 and 10. This vehicle is of five to six tons capacity and has several special features, chief amongst which are the boiler and engine, The former is of an improved patent fire-tube, centrally fired type, constructed wholly in mild steel. Exceptional steaming qualities are claimed for it, and special facilities are provided for internal inspection and cleaning, a most important feature having regard to the fact that foul water has frequently to be used in this class of work. A steam drier is incorporated in top of steam space, preventing priming, and ensuring a supply of dry steam to the engine. The boiler which contains 105 sq. ft. of heating surface and 4 sq. ft. of grate area, works at 200 lbs. to the square inch, and is hydraulically tested to 400 lbs. to the square inch. The engine is of the horizontal compound type, having cylinders of 4-in. and 7-in. bore respectively, with a common stroke of six inches. It works normally at 450 revolutions per minute.

It is fitted with link motion, and has extra large wearing surfaces. All working parts are completely encased in a dust and oil-proof casing and are self-lubricating, thus making the engine practically fool proof. Owing to the high grade of workmanship and material employed the engine may safely be run at a higher speed than its listed normal, thereby enabling a high road speed to be maintained on good roads or when running light.

Fitted on top of the cylinders are patent starting and hill-climbing valves which, controlled by the reversing handle, enable the driver to work his engine as a double high pressure, as well as compound, thus ensuring a start in bad places and the safe ascent of very stiff hills.

The gearing gives two ratios, one for level and easy grades, and one for heavy gradients. It is of steel throughout, and all teeth are machine cut. The gear wheels are securely bolted (not keyed) to the differential box.

The pump is of the dust and oil-proof encased automatic type, and is self-lubricating. It is worked, geared down, direct from the engine crankshaft, and can be used to feed the boiler whilst standing or when raising steam.

An injector is also provided. It is bolted direct to the boiler shell, and may be used to feed the boiler whilst standing or running. The water lifter, which is capable of filling the 165-gallon water tank in six minutes is bolted direct to the side of the water tank, and is controlled from the driver's seat. The bunkers contain sufficient coke for one day's run. The body is of the flat-top lorry type, constructed of oak with larch bottom, fitted with loose dwarf

FIG. 7.—LIQUID FUEL STEAM DELIVERY VAN BY ROBERT MORTON & SONS, LTD., WISHAW.

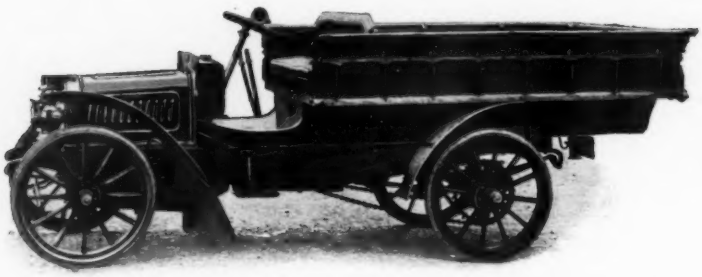


FIG. 8.—LIGHT COMMERCIAL VEHICLE BY THE ALBION MOTOR CAR CO., LTD., SCOTSTOUN.

railboard, iron protection bars and corner plates.

The height of the platform from the ground when loaded is 3 ft. 6 in., the body dimensions being 13 ft. long and 7 ft. wide.

The wheels are of the artillery type, with oak spokes, ash felloes and malleable steel hubs fitted with gun-metal bushes. The tyres are of steel set on hydraulically.

The main frame is of channel steel, well gusseted and stayed, and is rivetted throughout, no bolts being used.

A steam brake is fitted, acting direct on driving wheels, giving very great power; it is operated by a turn of the driver's wrist. The engine forms the second brake, and will hold the lorry on all reasonable hills.

The steering gear is of an improved Ackerman type, swivelling on hardened steel cod pieces, ensuring very safe and easy steering.

The axles are of special nickel steel, capable of withstanding very rough usage; no welds whatever are employed. The machine is a fine example of high-grade workmanship, and is the outcome of many costly experiments.

MESSRS. SAVAGE BROS., of King's Lynn, have recently brought out a standard steam wagon—a strong substantial machine, illustrated in Fig. 11. It may be constructed as a tip wagon or be fitted with the ordinary level platform. In the latter case the over-all dimensions of the vehicle are 18 ft. long by 6 ft. 6 in. wide, the platform, which stands 4 ft. from the ground, having an area of 75 sq. ft.

The lorry has been tested to carry its full load up a gradient of one in seven, and from figures supplied by the makers the coke consumption appears to work out at about 2 lbs., and the water consumption at about eight to ten gallons per ton mile.

The main frame is of channel steel stiffened with gussets and stays. The axles are girders of I section, the front one carrying the steering heads of the front wheels. The back axle is tied to the main frame on each side by adjustable radius rods which allow the side chains to be tightened when necessary. These rods pass through the back axle, and have double adjustment nuts on each side; where they pass through the axle, spherical bosses are rivetted to each side of the axle. The steering is arranged on the Ackerman principle, and the rod passing from wheel to wheel is carried in guides on the axle.

The wheels are of the artillery type, fitted with steel tyres which are shrunk on.

The boiler is of a special water tube type, and consists of an upper solid-drawn drum, with removable end covers, and of a bottom mild steel tube plate, with domed cover. These are connected together by eighty-nine bent "up" tubes, arranged in four rows, and expanded into the plates at each end. Above the upper drum, and connected with it, is a malleable steam dome chamber, into which fit a pair of safety valves, a throttle valve, a pressure gauge, and the pipe fittings for connecting it with the "Marsh" steam pump, with a water lift, and with the steam blast in the chimney. The heating surface provided by the tubes is 90 sq. ft., to which must be added another 4 ft. for grate area. The normal working pressure is 220 lbs. per sq. in., and it is preliminarily tested to a pressure of 400 lbs. per sq. in. A bunker having a capacity of 3 cwt. is provided to the left of the boiler, and the "Marsh" pump lies to the right.

The engine is of the horizontal, double-acting, compound type, with cylinders of 4 and 7 in. bore respectively, with a stroke of 5 in. The nominal output is 30 h.-p., and the normal speed is 450 revolutions per minute. The valves are of the piston type, and are both operated by a single eccentric.

The eccentric works direct on to the high-pressure valve, and is connected through a system of bell-cranks with the low pressure valve, which lies beneath its cylinder. The crank shaft projects across beneath the car on the left, and is of a squared section between the fly-wheel (which fits close up to the

crank-shaft), and an external spherical bearing on the frame which supports its extreme end. The squared portion carries a pair of sliding spur-wheels, which can be brought into mesh, alternatively, with corresponding wheels on a differential countershaft, from which the side chains pass to the rear wheels. Another spur-wheel is fixed to this end of the crank-shaft, and drives a feed pump.

The right end of the crank-shaft is hollow, the rod which varies the "cut-off" and causes the eccentric to reverse the direction of travel, passing through it. The differential is of the bevel wheel type, and provision is made by means of a pin-clutch for locking it from the driver's seat when required. Speeds of 5 and 2·8 miles per hour respectively are obtained when the engine is running at 450 revolutions per minute. The cylinders are lubricated by a Rochester pony lubricator, which feeds oil into the high pressure steam-chest, proportionately to its speed, when the engine is running.

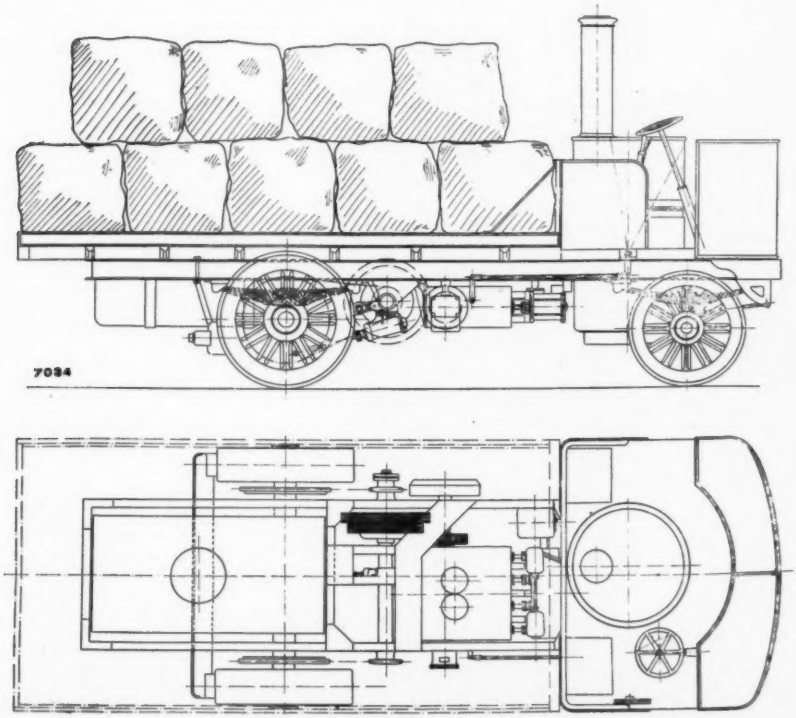
The side chains, which are enclosed, are of the Hans-Renolds pattern, tested to 25 tons, and have a 2¼ in. pitch.

The large sprockets are connected to the road-wheels at three points, through specially designed spring cushion devices, which are constructed so as to allow the engine to make one complete revolution before the road-wheels are compelled to move.

The delivery from both pumps is led through a specially constructed feed-water-heater, the water passing through a copper coil contained inside a copper cylinder; the water is heated by the exhaust steam which is led through this cylinder.

The water tank is placed beneath at the rear, and, when a tip wagon body is fitted, it is specially shaped about the back axle; its capacity is about 150 gallons, sufficient for running a distance of fifteen miles without re-filling.

Messrs. Robertson & Son, of Fleetwood, make a speciality of a standard 5 ton wagon, one of which, fitted with a tipping body and gear, forms the subject of Fig. 12. The general dimensions of the wagon are as follows: Total



FIGS. 9 AND 10.—5-6-TON WAGON BY THE GLASGOW MOTOR LORRY CO., LTD.

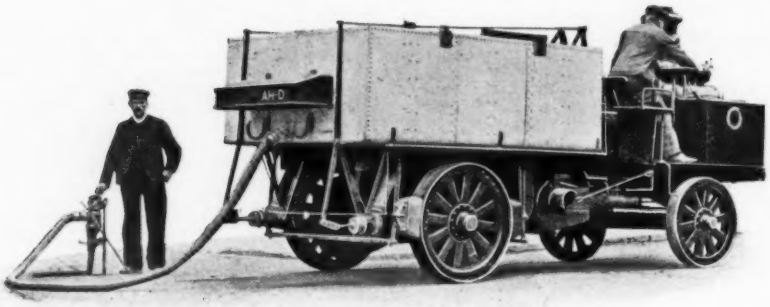


FIG. II.—STANDARD STEAM WAGON ARRANGED AS A SANITARY CAR: MESSRS. SAVAGE BROS., KING'S LYNN.

length, 18 ft. 9 in.; total width, 7 ft.; height of platform when light, 4 ft. The body, which is of ash framing, has an area of 86 sq. ft. The driving axle is of special design, held in position by strong radius rods attached to the steel pedestals of the second motion shaft.

The engine is of the horizontal compound reversing type, with cylinders of 4 in. and 7 in. bore respectively, with a common stroke of 5 in., and runs normally at 433 revolutions per minute, developing 25 B.H.P. An auxiliary valve is also fitted, admitting live steam to the L.P. cylinder, giving additional power when required for getting out of difficult positions.

The gearing is of steel, the ratios provided being 10 and 17·8 to 1. The crank shaft, outside the engine box, is of square section, on which slides a steel double pinion, which is moved into mesh with the steel wheels on the differential gear shaft, and from this shaft, with a sprocket wheel at each end, the power is transmitted to the larger sprocket wheels by Renold's chains.

The differential gear is locked by a steel clutch, actuated from the end of the differential shaft.

The boiler is of the "Robertson" patent multitubular fire-tube type, is centrally fired, and is constructed for a working pressure of 200 lbs. per sq. in. The grate area is 3 sq. ft., and the heating surface 80 sq. ft. The boiler is specially designed so that all the tubes are completely under water, and are fixed radially between the fire-box and the outer shell, this outer shell being almost completely enclosed by the smoke-box casing. The outer casing is easily removable, without disturbing any of the boiler fittings, and all the tubes can be readily got at for cleaning and for repairs.

The fire-bars, with the ashpan, are slung in position by steel wire ropes, and are raised or lowered as required for cleaning or lighting purposes by suitable worm gearing, which is locked when in working position. This arrangement eliminates the fire-door, with its objections, and facilitates cleaning flues, &c., and gives immediate access to the fire-box.

The feed heater is of special design, with brass body, brass tube plates and tubes, and is capable of heating the feed-water to 190° Fahr., the condensed steam being filtered and returned to the tank.

The main feed pump is situated alongside the engine casing, and is driven by the crank-shaft through reducing gearing enclosed in the engine box, and running in oil, and is amply sufficient for supplying the boiler. A separate auxiliary feed pump or injector is also provided, having separate steam and water connections.

The wheels are of either artillery, composite or all steel type, having steel rims and naves, the latter bushed with hard gun metal bushes. The dimensions are as follows:—

Front wheels, 2 ft. 9 in. dia. by 6 in. wide.
Driving wheels, 3 ft. 3 in. „ 10½ in. „

The steering gear is worked on the Ackermann principle, and is actuated by a vertical screw, having double square thread engaging in steel case hardened nut on to the shaft.

In addition to the reversing lever, an efficient brake is provided, working on the inside of the large sprocket wheels, and controlled from the driver's seat.

A water lifter is fixed on to the water tank, and is fitted with 30 ft. of wired suction hose, with strainer attached.

The water tank has a capacity of 195 gallons, and is fitted with indicator cocks and hand-filling attachment.

One month's working of one of these vans showed the following results: Total load carried, 177 tons; total miles run, 583; total ton mileage, 3,126·73; hours under steam, 269; Coke used, 111 cwt. One cwt of coke averaged 2·4 hours for the wagon under steam.

When arranged as a tipping wagon the body is constructed of oak framing, with

larch sides and bottom, and has a capacity of 144 cubic ft.

The tipping gear consists of a hydraulic cylinder and ram, the auxiliary steam pump being arranged to force water from the tank into the cylinder for raising and lowering the body, and the supply of water is controlled by a specially-designed valve, which regulates it either to raise or lower the body or supply the boiler. All the water used is returned to the tank, so that no loss of water occurs. The tipping gear can also be actuated by the main feed pump if required.

A Combined Solid and Pneumatic Tyre possessing several interesting and novel features has recently been introduced by the Herald Manufacturing Co., Limited, of Manchester, and is illustrated in sections in Figs. 13—15. As will be seen it consists essentially of a steel ring of special section, an outer solid rubber tyre, and an inner pneumatic tube. The outer tyre is secured to the rim by metallic slides provided with a shoulder or lug at each end: both tyre and slides being free to spring or "give" when rolling under a load. The tyre cannot on the one hand be forced out of the rim by any strain received in travelling, or, in the event of the air tube being insufficiently inflated, be pressed far enough inwards to damage or pinch the latter.

The durability of the outer solid rubber tyre is greatly increased by the air tube, which, by its elasticity, helps to neutralise the effect of the concussions or shocks received by the tyre. The air tube has free play within the rim, receiving over a large surface the pressure transmitted by the outer tyre. The friction of the lateral metallic slides against the rim edges is practically negligible, and the consequent wear of these slides very slight. This is due to the elastic nature of the rubber, and to the fact that the movement of the slide is, except when the car is turning, parallel with the rim edges.

The tyre has been found to compare favourably with the ordinary pneumatic. It is well known that to obtain good results with the latter it is necessary to inflate them to a high pressure, whereby some of the benefit secured by their use is lost: the higher the pressure the nearer they approach to the solid in effect.

During comparative trials, it was clearly perceptible that in passing over a stone or other obstacle, less of the surface lengthwise of the "Securitas" was raised clear of contact with the ground, than was the case with the ordinary pneumatic; also that the "Securitas" had, at any given moment, a greater length of its surface in contact with the ground. These properties increase the tractive power, and do not diminish the speed.

The danger of a forced stoppage, in the middle of a journey, for repairs, is constantly present where the ordinary pneumatic tyres are used: accidents and stoppages are more often due to their collapse than to any other cause.

The driver of a car fitted with the "Securitas" tyre has at his disposal two systems which can be replaced, the one by the other, immediately, both of which, we are informed, work perfectly. The outer tyre in its travelling or rolling function is entirely independent of the inner air tube, and is unaffected by anything which may happen to it. A puncture of the air tube is practically impossible, but in the event of the tube becoming deflated through any cause, such as a leaky valve, the journey may be continued without stopping. Immediate repairs are not necessary to the inner tube, so that, should deflation take place, the

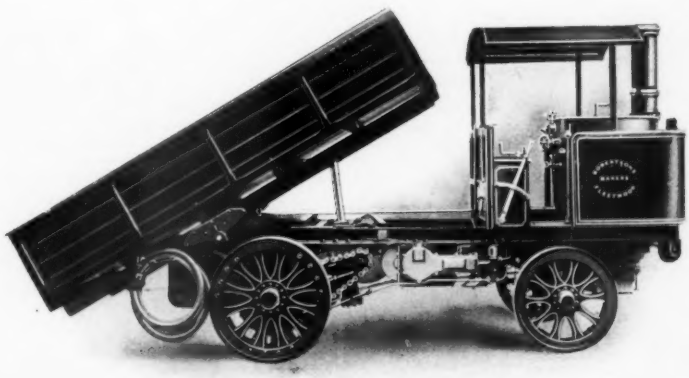


FIG. 12.—5-TON TIPPING WAGON BY MESSRS. ROBERTSON & SON, FLEETWOOD.

FIG. 13.—THE "SECURITAS" COMBINED SOLID AND PNEUMATIC TYRE.

outer tyre recedes automatically inwards and the outer shoulders of the metallic slides grip the rim edges. The car then travels on a comparatively solid tyre and without injury to the air tube.

Side slip is the cause of many accidents in the case of cars fitted with either pneumatic or solid tyres. The unavoidable widening of the tread in the case of the former reduces its capacity to resist side slip. The advantage claimed for the "Securitas" tyre with regard to resistance to side slip is accounted for by the increased length of tyre in contact with the ground, and, as compared with the pneumatic, to its narrow tread. The "Securitas" is not subject to this widening of tread.

The wired outer covers of pneumatic tyres tend to tear away in turning a corner at a high speed, or when side slip occurs, or side strain from any cause is produced, and the pull, which is considerable, is concentrated on one point at the bottom of the rim. The collapse of pneumatic tyres in consequence of this tendency, has in numerous instances led to serious results, In the "Securitas" the opposite effect is produced, the part of the tyre in contact with the ground being pressed within the rim, carrying with it the inner or holding shoulders of the slides. The greater the strain the farther the tyre recedes within the rim, and instead of the pull the tyre recedes within the rim, and instead of the pull being concentrated on one point, a large proportion of it is absorbed by the air tube, and by it spread over the whole of the rim.

Special provision is made in the metallic slides to prevent creeping, also the whole of the pressure in the air tube is utilised to force the slides outwards against the retaining edges of the rim, thus ensuring a firm hold between tyre and rim. It may be said, in addition to this, that when any of the holding shoulders of the slides are pressed inwards, either by contact of the tyre with the ground or through the application of the brake, the remaining slides grip the rim with increased force. For these reasons the tyre is free from the defect of creeping.

FIG. 14.

FIG. 15.

THE "SECURITAS COMBINED SOLID AND PNEUMATIC TYRE.

An Improved Petrol Engine.

It has been stated that many of the motor omnibuses at present running are slightly underpowered, with the result that although the engine accomplishes its work, it does so at the expense of durability. Particular attention has been given to this point in connection with the design of a new omnibus by Mr. A. E. S. Craig, of the Putney Motor Co., Limited, London, S.W., a transverse section of the engine of which is shown in Fig. 16. In this engine, known as the "Ailsa Craig," four cylinders are provided of which the stroke and bore are respectively $4\frac{7}{8}$ in. and 5 in. These develop at a speed of 900 revolutions per minute 32 h.-p. In such an engine there is a reserve of power useful in getting away, at the same time economical working is secured under ordinary conditions. That there is a gain in durability will be obvious. Some of the features of this engine are of interest. Self-oiling ring lubrication has been provided to the crankshaft. The magneto, the pump and governor, are all combined with the engine and driven by cased-in gears. Fan gear with self-tightening belt is attached to the motor, thus making the engine in every respect complete

in itself. Clean castings in water jackets are insured by having large gun-metal inspection domes fitted over the combustion heads. Large diameter valves of chilled fine grained cast-iron, fitted in a special manner to steel spindles give excellent results, a hard burnished skin being found on the seatings. The latter, after months of hard wear, shows no sign of pitting. Another interesting point to which attention might be called is the method of fixing the gudgeon pins, enabling the light pistons machined all over inside to be used. The method of lubricating gudgeon pins is another important feature, as it keeps this part of the machine well supplied with fresh oil, the residue flowing down and so lubricating the big ends. A mechanical dredger-system oiling machine automatically supplies the desired amount of oil to each part of the engine. The crank-shaft is of large diameter in order to avoid torsion, and the bearings throughout, which are of special bronze, are also of very ample proportions.

ANOTHER type of steam wagon with which first-class results are being obtained is that known as the Londonderry vehicle. It is made by the Seaham Harbour Engine Works, and an example specially constructed for mill requirements is shown in Fig. 17. The standard wagon is of 5 tons capacity, having a total length of 19 ft. with a width of 6 ft. 6 in., the height from the ground to the body bottom being 3 ft. 10 in. The frames are of steel channels suitably braced. A feature of interest is the wheels, which are either of wood or cast steel as preferred. Wood wheels are cut from teak, and are hooped with rolled steel tyres fitted with protection plates. Steel wheels are solid cast, with no rivets or joints. The back pair are 3ft. 3 in. in diameter, with 10 in. tyres; the front pair 2 ft. 9 in., with 6 in. tyres. The boiler is of the central fired vertical smoke-tube type working at a pressure of 200 lbs. The ordinary working water level is 1 ft. 9 in. above the fire-box crown, and the boiler contains 95 sq. ft. of heating surface and an additional 3½ sq. ft. being provided by the fire grate. Cleaning facilities are provided by the removable smoke-box, which exposes the whole length of tubes without disconnecting any steam joints. The feed water is raised to 180° by means of an exhaust steam heater, and is delivered by an automatic feed pump driven from the crank-shaft. The engine is of the horizontal compound type, valves being actuated by the firm's patent single eccentric gear with constant lead with variable cut-off. The diameters of the cylinders are respectively 4¼ in. and 7 in., with a 7 in. stroke. Both cylinders can be worked with steam direct from boiler, but the engine is sufficiently powerful to do its duty running compound under all ordinary circumstances. Lubrication of the engine is of the splash principle, but slide valves and cylinders are oiled automatically by a positive feed pump lubricator. The two-speed gearing permits of speeds of 5½ miles per hour and 2½ miles per hour. The water capacity is 220 gallons, which is equal to a 25 miles load run. The bunker capacity is 4 cwt. coke. The stearing gear is of patent worm and quadrant design, with only four working joints. Ball bearings and ball socket joints facilitate steering and counteract uneven motions on rough roads. The brake is of the screw down type, and will bring the vehicle to a dead stop within 20 ft. on the steepest incline. A recent test showed that from March 13th to April 19th, sixty journeys were made and 654 miles travelled, the weight

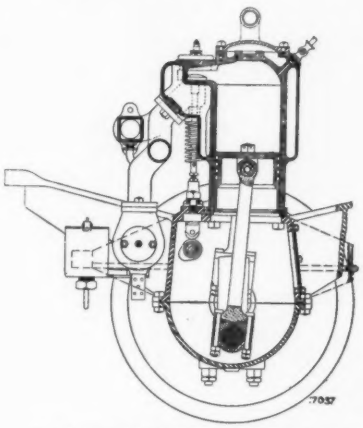


FIG 16.—THE "AILSA CRAIG" PETROL ENGINE. TRANSVERSE SECTION.

carried being 274½ tons. Washing out occupied 1½ days and repairs 1 day; the cost per ton mile worked out at 2*d*.

THE latest type of steam road wagon introduced by Messrs. T. Coulthard & Co., Preston, is that known as Class K. It complies in all respects with the requirements under the new regulations issued by the Local Government Board, and in general design is in accordance with the illustration. Fig. 18. Its capacity on good macadam and paved roads and on gradients up to 10 per cent. is 5 tons, with an additional load up to 3 tons on a trailer. Working singly the wagon can carry 6 tons. The leading dimensions are—length, 19 ft. 4 ins.; width, 7 ft.; the platform standard 13 ft. by 7 ft., giving 91 sq. ft. area; tare weight, 4 tons 19 cwt. The main frame of the wagon is of channel steel, having strong cross-channel braces, and the whole being supported on the axles by extra long laminated springs. The spring ends are provided with sliding scrolls free to move on corresponding hard metal pads secured to

FIG. 17.—5-TON STEAM MOTOR WAGON BY THE SEAHAM HARBOUR ENGINE WORKS.

the frame, an arrangement which ensures that smooth working of the springs is not effected by any wear of the plates. The steering is of the Ackermann type, the power being applied by worm and wheel, which work in an oil-tight casing. The wheels are of artillery pattern with steel tyres hydraulically fitted, their dimensions being: Rear pair, 3 ft. diameter by 11 in. face of tyre; front pair, 2 ft. 9in. in diameter by 6 in. face of tyre. The boiler is Messrs. Coulthard's patent vertical fire-tube type, working at a pressure of 200 lbs. and hydraulically tested to 400 lbs. The upper tube-plates of the fire-box crown are stayed with the central tube of sufficient diameter to form a central firing shoot. The shell is arranged with two bolted joints, so that the upper part may be readily removed for inspecting and cleaning the tubes. The fire-bars are of a patent hinge type so arranged that when necessary the fires can be instantly dropped. The main boiler feed is by a dust-proof ram pump directly connected to the engine, and a steam pump is also fitted as an emergency feed. The tank capacity is 160 gallons, sufficing for a run of from 12 to 15 miles. The engine is of compound type, with link reversing gear developing 30 B.H.P. A special valve is provided whereby live steam can be admitted direct to the low pressure cylinder. All the motion is in an oil-tight casing, which encloses also the reduction compensation gear. An important feature is the method of suspending the engine and casing in the frame. The cylinder end of the combined engine and gear casing is secured to the frame by a double knuckle joint, whilst the other end is carried by slide channels of the frame in large overhung bushes, these in turn being carried in spherical bearings, the bushes forming the bearings for the compensating shaft and sleeve. This method of suspension ensures alignment of the various shafts, notwithstanding a distortion of the frame owing to load or road effects.

The following shows the details of a week's work which is still being regularly done by one of this type of wagon:—

—	Miles.	Tons.	Cwts.	Qrs.	Lbs.	Rail rate and Cartages.	£	s.	d.
						s. d.			
Monday and Monday night	54	6	0	0	0	11 6	3	9	0
	54	4	4	2	20	9 2	1	18	10
Tuesday	18	4	15	3	2	7 4	1	15	1
	7								
	17	5	5	3	26	6 2	1	12	8
Wednesday and Wednesday night	54	6	0	0	0	11 8	3	10	0
	54	3	16	3	1	9 2	1	15	3
Thursday.....	11	7	11	0	13	6 5	2	8	6
	11								
	12	4	11	0	24	7 2	1	12	8
Friday and Friday night.....	54	6	0	0	0	11 6	3	9	0
	54	3	17	0	0	9 2	1	15	4
	400						£24	5	11

Average load over 400 miles. 4·90 tons per mile.
Average load over 382 miles. 5·13 tons per mile.

400 miles,
Less 18 ... light.
382

FIG. 18.—COULTHARD'S CLASS "K" 5-TON WAGON.

THE YORKSHIRE PATENT STEAM WAGON CO. of Hunslet, Leeds, have now been established over four years, during which period upwards of 100 motor lorries have been sent to all parts of the British Isles and colonies.

The firm have not considered it necessary to greatly alter the general design of their standard type of wagon, which is fully described by Mr. F. F. Bennett on pages 46 to 52 of this issue. In appearance it is very similar to the first one built, but every improvement that experience and practice have suggested has been

adopted, and the firm have, as time has gone on, eradicated many small weaknesses, re-arranged a few of the details, and given more boiler and engine power.

During the past year they have, in response to requests from their numerous clients abroad, placed upon the market a new type of wagon in which every moving part of the mechanism is enclosed and efficiently lubricated by a combination of forced and splash lubrication, the object being to build a wagon which can be put into the hands of an unskilled man without risk of injury from want of knowledge or inattention, the driver having practically nothing to do, except drive and steer his wagon, and replenish the oil bath at stated intervals of a few weeks.

This wagon differs in many other respects from their original type, being fitted with an additional intermediate shaft and gearing, and all gearing and brackets of the driving axle are fitted with swivelling motions so that the alignment of the mechanism is not affected by any inequalities of the road.

THE LANCASHIRE STEAM MOTOR CO., LIMITED, of Leyland, was one of the first firms to take up the manufacture of steam and petrol motor vehicles, having commenced operations as far back as 1896. The present output of this company comprises two standard classes of vehicles, viz., class B. and class G. The first of these, an example of which is given in Fig. 19, is designed for a load of four tons and the second for a load of six tons. The boiler is of the fire-tube central feed type, having 110 sq. ft. of heating surface, and 4·9 sq. ft. of grate area, and works at a pressure of 200 lbs. per sq. in. Cleaning facilities have received ample attention in this design which includes an upper and lower shell, the latter containing the fire-box, the crown of which is supported by a central tube, which is also used for feeding the boiler with fuel. Attached to the central tube is the top tube plate, the fire tubes being expanded in the furnace crown and the upper tube plate. The upper shell can be readily disconnected, exposing the whole length of the tubes. Attached to the top tube plate is a steam drier. Under ordinary working conditions—*i.e.*, when the gauge glass is half full—there is 14 in. of water above the furnace crown, so that there is no fear of this being burnt. For cleaning the tubes all that is necessary is to disconnect the chimney, which is attached to the smoke-box top; this then exposes the whole length of the tubes for cleaning purposes.

The engine is of the compound horizontal pattern, with cylinders $4\frac{1}{2}$ in. and $7\frac{1}{2}$ in. bore by 7 in. stroke, and is capable of developing 45 h.-p. at 450 revolutions. The whole of the bearings are non-adjustable, the makers claiming that the bearing surfaces are so unusually large that adjustment will not be required for years, at the end of which time renewable bushes can be inserted. It is claimed that the advantages of such bearings are that unnecessary loose parts are dispensed with, and also that the possibility of tampering with bearings is removed. The ratios of the gearing between the engine and the road wheels are as follows; Fast speed 11·35 to 1, giving a speed of 5·6 miles per hour; and slow speed 24·46 to 1, giving a speed of 2·6 per hour. The whole of the engine is enclosed. The valve motion, instead of having the radial link, has a straight slot, and the makers claim that a better diagram is thus obtained under all conditions of working. The road wheels are of composite pattern, with cast steel hubs and spokes, ash felloes, and weldless steel tyres. The driving wheels are 3 ft. 9 in. diameter, with 10 in. tyres, and the steering wheels are 3 ft. diameter with 6 in. tyres. The frame of the wagon allows of a platform up to 16 ft. long and 6 ft. 6 in. broad. The steering gear is a modification of the Ackermann type, operated by handle, worm, and worm wheel. The brakes are powerful, and operate inside the chain rings on the driving wheels.

The Peebles Railway Steam Motor Car.

THE success achieved by Messrs. Ganz & Co., of Budapest, with their latest form of steam railway motor cars on the Continent has resulted in the formation of an English company, who have entered into an arrangement with Messrs. Bruce Peebles & Co., Ltd. to build the necessary engines and equipment under these patents, which are fitted to cars built by the leading tram and railway car builders in England.

The motive equipment consists of a light high-duty water tube boiler of special construction, supplying steam to a compound engine, working at fairly high speed on superheated high-pressure steam. The car body is of comparatively light construction, approximating rather to the tramcar style of body, though more roomy and lofty inside and, of course, single-decked. Thus the live paying load of this car is stated to bear a higher proportion to the dead weight of car and equipment than is usual either among ordinary passenger coaches or among the self-propelled cars that are already in service on British railways. Where specially high speeds or other conditions render it desirable, a stronger and more substantial body is adopted.

The engine is hung from the underframe of the car, much as an electric motor is suspended, it is thus possible by loosening a few bolts to remove it and the gearing for inspection without interfering with the truck and wheels. The use of gearing may be something of a novelty on British railways, but when it is remembered that it is universally adopted on electric railways, giving complete satisfaction, and that but for its use a very much heavier motor would

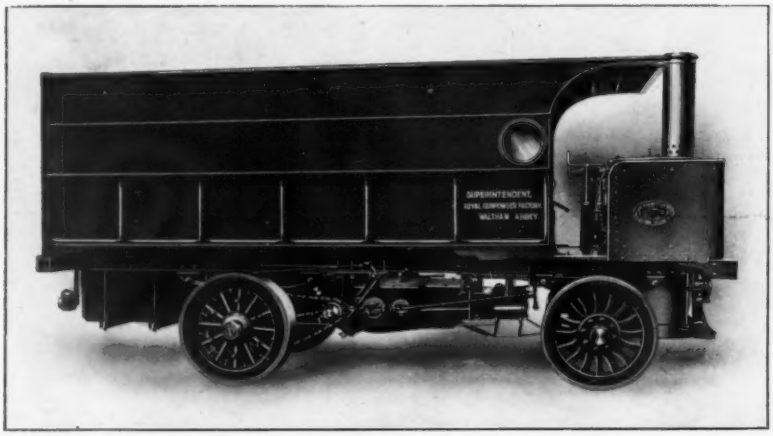


FIG. 19.—4-TON STEAM WAGON BY THE LANCASHIRE STEAM MOTOR CO., LEYLAND.

have to be adopted to produce the necessary tractive effort at starting and uphill, there can be no objection to its use. Further advantages of driving through gear are that the impulses on the driving wheels are made more uniform and the co-efficient of adhesion accordingly increased, while swinging or oscillation of the car is reduced.

The boiler is placed in the middle of the driver's compartment at the end of the car, and has about eight hundred small tubes. It is designed to work at a pressure of 260 to 300 lbs. per square inch, which can be obtained in twenty to thirty minutes with either coke or Welsh coal.

The fuel is introduced through the funnel formed by the inner walls of the boiler, and the ash-pan can be emptied by means of a foot lever. A door is provided to regulate the draught and facilitate the cleaning of the boiler.

The boiler can be removed and replaced with a spare one with great facility, thus, should any repairs be necessary, the car is not put out of service.

The overall dimensions of a standard boiler, sufficient to supply a motor rated at 35 h.-p., are 32 in. diameter by 45 in. high.

The engine is of the cross compound type, with steam-jacketed cylinders. The smaller standard size has cylinders 4·7 in. and 7 in. by 5½ in. stroke, and at 600 r.p.m., working compound, gives an output of 35 B.H.P.; larger motors, of 50 and 80 B.H.P., are also built for heavier cars. Slide valve gear of the simplest order, and suited to high speed running, is employed. A bye-pass valve is provided, so that at starting boiler steam can be admitted to both cylinders

All the working parts are contained in a water and dust-proof casing, and run in an oil bath; and only 10 to 12 lbs. of oil is used per month. Lubricating oil is conveyed to the cylinders under pressure, and about an ounce is used for a ten-mile run.

The driver's stand, beside the boiler, is fitted with three levers, one for governing and reversing the steam motor; a second for controlling the bye-pass valve, allowing the engine to be run as compound or twin cylinder; while the third actuates the clutch on the crank shaft, which brings the gearing into action.

The smaller cars are fitted with powerful hand brakes, acting on all the wheels at once. Should the car be above a certain weight, or the running speed and gradients require it, air or vacuum brakes are fitted.

Arrangements are made for the control of the car from both ends, in order that it may run in either direction. This is equally the case whether one or two motors be fitted to the car.

Where two motors and boilers are fitted, both boilers are arranged together at one end, for convenience in stoking and handling.

The feed water tanks are two in number, placed one on each side of the boiler, and hold about 250 gallons. The feed pumps are in duplicate, and are of the direct acting type, automatically regulated. The oil pumps are operated from the same crank shaft as the feed pumps.

As will be readily understood, the motor is equally applicable to standard and narrow gauges. Numerous cars are in service on lines of only 2 ft. 6 in. gauge; and as the motor takes but little transverse space it can readily be adapted to even narrower gauges, such as largely used on light railways.

The car bodies are of the most modern construction in every particular, and are fitted with steam heating and electric or acetylene light.

The seating accommodation of the cars now in service varies from a minimum of thirty in the smallest to a maximum of a hundred in the largest double bogie types. In addition to this, the motors are of ample power to haul trailers at the hours of busy traffic.

On the Hungarian State railways, where thirty cars have been running for eighteen months, the results of working have been eminently satisfactory, the total working costs having been reduced to 5*d.* per car mile, and the number of passengers carried increased by about 27 per cent. The following particulars of cars running on the Debreczen-Tiszalok and Debreczen-Kaba Nadudvar branch lines are the latest results to hand and show a very great saving indeed over the old system of ordinary train service which it has replaced.

Three cars ran from 1st September, 1903 to February, 1904, and five cars ran from 1st March to 26th August, 1904.

The total car mileage for the twelve months was 97·100; the total trailer mileage for the twelve months was 70·600; and 395,000 passengers were carried at a cost of 5·03*d.* per car mile, the costs being made up as follows:—

	Per Car Mile.
Fuel	2·24*d.*
Lubrication	0·15*d.*
Other stores and material ...	0·027*d.*
Wages	0·97*d.*
Maintenance and repairs ...	0·534*d.*
Management and general charges	1·11*d.*

The Avonside Rail. Motor Car.

THE Avonside Engine Co., of Fishponds, Bristol, claim to be the first manufacturers of steam motor cars in Great Britain, and they have now standardised a series of sizes of from 2 ft. to 5 ft. 6 in. gauge, so as to be able to manufacture cheaply and quickly.

One of the features of these cars lies in the very large proportions of actual heating surface, so that the boiler is never forced and consequently not only is dry steam produced but the boiler lasts much longer. A great advantage possessed by the Avonside Co.'s system is that the engine can be removed from the carriage portion by the use of two jacks and four men in twenty minutes—thus enabling the engine to go into the repair shops without the whole car. Where a number of cars are in use a spare engine can be put in and the car run again at once. The carriage underframe and bogie is specially designed to prevent rolling and has proved so satisfactory that a main line 9″ car has been run backwards at forty-five miles per hour without any appreciable movement.

The car is carried on two bogies, thus reducing the weight per axle. Further, lighter rails can be used, and less wear and tear caused owing to the small fixed wheel base and easy running.

The carriage portion of the car depends entirely on what class of work it is desired to do, this varying from a simple tram car type to a most elaborate private saloon, Engineers'

FIG. 20.—THE PEEBLES RAILWAY STEAM CAR.

construction and inspection cars are also made. These are divided into a kitchen, bedroom, and living room, which enables the engineer to be quite independent of any outside conveniences.

For surburban work a car can be either wholly one class and holding a large number of passengers or divided into two classes with or without a luggage compartment.

For colonial and foreign or branch line work the most suitable type appears to be that divided into two classes and a luggage compartment.

One or two trailers can be handled easily by any of the coupled cars, but it is not usually considered advisable to use more than one on the single car unless the line is very flat.

The International Tramways Exhibition.

THE third International Electric Tramway and Railway Exhibition, which was held at the Agricultural Hall, Islington, early in the month, compared very favourably with the two preceding exhibitions held under the same management in 1902 and 1900 respectively, in spite of the fact that two or three of the largest firms did not exhibit. The exhibition was formally opened by the Earl of Derby. A luncheon was subsequently held, at which Mr. J. W. Courtenay, chairman of the Exhibition Committee, presided. Among those present were Sir Edward Monson, Mr. Alexander Siemens (president of the Institution of Electrical Engineers), Mr. R. Hadfield (president of the Iron and Steel Institute), Sir C. Rivers Wilson, Sir Guilford Molesworth (president of the Institution of Civil Engineers), the Hon. Arthur Stanley, M.P., Lieut.-Colonel H. A. Yorke, Mr. Alfred Baker (president of the Municipal Tramways Association), the Lord Mayor of Dublin, the Mayors of Brighton, Warrington, Luton, Colchester, Eastbourne, Reading, Lincoln, Bury, Southampton, Exeter, and other towns. In submitting the toast of "The Industry of Transport," Lord Derby observed that it was one of the greatest problems upon which in all times the progress of mankind had depended. He gave some instructive figures showing the development of tramways, which may be set out in tabular form thus:

Year.	Miles Open for Traffic.	Cars, Horse.	Cars, Electric.	Passengers.
1878.....	269	1,124	—	146,000,000
1903-4....	1,840	2,336	7,123	1,799,500,000

Lord Derby also quoted a table dealing with the present-day electric traction, 1898 the height of the steam period and 1879 the horse period of the tramway:

	1903-4.	1898.	1879.
Capital expenditure per mile of single track	£16,018	£10,649	£9,877
Percentage of net receipts to capital outlay	6·27	6·38	3·97
Percentage of working capital to gross receipts ...	66·15	76·93	83·81
Passengers carried per mile of route open	977,951	806,703	469,641
Average fare per passenger...	1·11*d.*	1·23*d.*	1·84*d.*

His lordship pointed out, in conclusion, how great was the future for electric traction in local haulage.

As for the exhibits themselves many improvements, chiefly in points of detail, were to be discerned, while developments on a large scale were to be noted in connection with the system of regenerative control, in the application of electric traction to railway work, and to the prominence of the surface contact system.

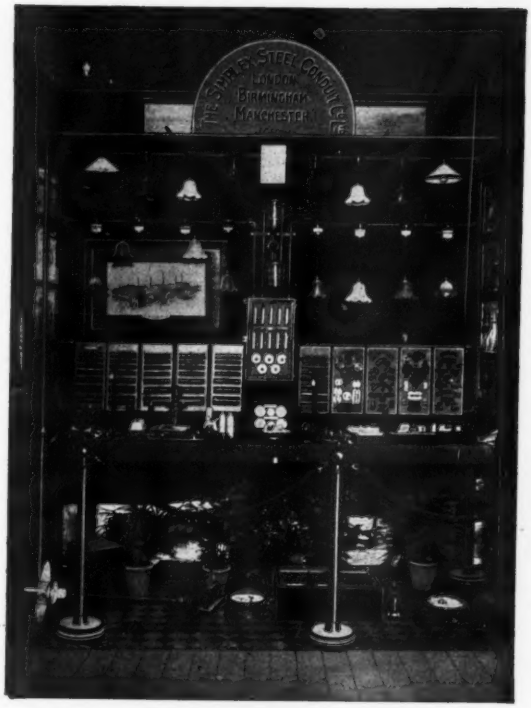
With regard to regenerative control—one of the most interesting problems in electric traction—Messrs. Raworth's system of successfully utilising the potential energy stored in a moving vehicle when descending an incline was exhibited. It is claimed for this system that the various details of equipment are less complex and more economical in operation than the series-parallel system, and that at the same time it gives absolute and perfect control of the car under all conditions of weather and on any grade, whether the trolley is on or off the line. The system has a further strong recommendation in its favour by reason of the fact that as the braking is done by the motors, no mechanical brakes are required except for the simple purpose of holding the car when a stop is made on a grade. By merely moving the operating lever of the controller forward or backward, the car is either accelerated or retarded as required. These features, however, by no means exhaust the advantages claimed for the system, which also affects the feeders and power house. Where power is regenerated by the cars down every grade, the effect upon the feeder cables becomes important, and conductors of reduced size can be installed,

The influence of tramway development on railway work was strikingly shown in various exhibits. The continuous current motor has hitherto been prominent for railway service in this country, but success achieved on the Continent and America with single and three-phase systems have led to an installation being made by the Portmadoc, Beddgelert, and Snowdon Railway. The three-phase locomotive for this line was exhibited by Messrs. Bruce, Peebles & Co.

Interest attaches to the surface contact system, of which working models were shown by the Traction Corporation, Limited, and the Dolter

Electric Traction, Limited. The Dolter system, which is in successful operation at Paris and Dresden, consists of a skate suspended from the under part of the car; this makes contact with a small iron block embedded in the road. Each of these blocks form the upper part of a circular pot or chamber which is watertight. Inside this chamber is an arm or lever, the top portion being of iron and the bottom copper, with an insulated strip between. A small piece of fusible wire is placed between these points for making electrical contact: the upper part of the arm of this lever is magnetically attracted immediately the skate comes in contact with the stud, thus making a connection with the cable.

The contact pieces are worked by gravity, and there are no springs of any description whatsoever. As a further preventative against the possibility of the lever failing to fall back, and, therefore, not breaking connection, there is a small separate skate at the end of each car which is directly connected through the framework of the car with the wheels and rail. This arrangement forms an effective safety device; further, should the safety device, in the event of a stud being left alive, blow the fuse in the contact box and so cut the faulty box out of circuit, this blowing of a single fuse will consequently not affect the working of this system as a whole, for there will always at least be two contact studs under each car. One of the advantages of this system is that the studs can be taken up and replaced with either a fresh stud, or a new fuse replaced, as the whole operation can be done in less than two minutes.



SIMPLEX STEEL CONDUIT.

MASON'S GAS POWER CO., LIMITED, LEVENSHULME. This exhibit consisted of 120 h.-p. Duff-Whitfield gas producer and a 40 h.-p. suction gas plant. The gas producer constructed under the Duff & Whitfield patents are continuous in their operation and produce clean gas of an uniform quality from bituminous slack coal. The characteristic feature of the system is in the method of dealing with the volatile products of the coal. The tarry vapours are drawn from the upper part of the fuel chamber and injected by means of steam into the incandescent coke in the zone of combustion, the main outlet for the gas from the producer being placed at a lower level than heretofore in order to permit of that operation. In this way the sensible heat produced by the combustion of the solid carbon is utilised to decompose both the tarry vapours and the steam by which they are injected into the fire, this decomposition producing hydrogen and carbonic oxide without dilution with nitrogen.

THE SIMPLEX STEEL CONDUIT CO., LIMITED. The stand of this firm occupied some 50 sq. ft. in the main hall and consisted of a rectangular framework built up of the firm's well known tubes or conduits and fittings. In the centre at the back was a five way D.P. fuse and S.P. switchboard in an iron case forming the controlling board for the various lights on the stand.

The exhibit, which was part of the stand shown at the International Exhibition of Paris, 1900, included pendant, lampholder, ceiling-rose and switch fittings, all of which were wired as in actual practice. Sample boards on the stand showed the six grades of simplex conduits, in both the enamelled and galvanised types, and the more common types of fittings, such as bends, tees, junction-boxes, &c. Many

new features and improvements which have been introduced into the system were shown on the table in front, such as multiple switch boxes, adaptable boxes, watertight fittings, main switches and cut outs, and distribution boards for use on circuits up to 25 amp. capacity. At the sides of the stand were shown photographs of simplex conduits in actual installation, and the whole exhibit was well up to the usua' high class stands invariably shown by the company.

GLACIER ANTI-FRICTION METAL CO., LIMITED, 91, Queen Victoria Street, E.C. This firm exhibited samples of their anti-friction metal in ingot form. This metal it may be mentioned is specially suitable for tram and railway bearings, and is, we understand, giving universal satisfaction for this class of work. Owing to

GLASIER ANTI-FRICTION METAL.

its extremely low co-efficient of friction it is also very extensively used by manufacturers of high speed machinery, and on account of its exceedingly tough nature it is also used for bearings of machinery working under very heavy strain. Ingots of Findlay's special motor metal which is especially prepared for armature bearings were also shown, a display of bearings, lined with Glacier metal illustrating the application to different classes of work completing the exhibit.

THERMIT, LIMITED, 27, Martin's Lane, Cannon Street, E.C. The stand of this firm was rendered additionally interesting by the daily demonstration of the alumino-thermic process of tramrail and tube welding. On the stand itself were shown all the materials and appliances necessary for carrying out the process, the striking feature of which is the simplicity of the apparatus required. That necessary for tramrail welding consists of a crucible, tripod with tapping spade, bag containing the welding compound, tin of ignition powder, rail clamps, moulds and mould clamps. The moulds are made locally. The crucible stands from 30 to 40 charges and can then be re-lined. For repair work clamps are dispensed with. The method of procedure is as follows: The rails, having been laid to true level and alignment, are heated by means of a blow-lamp and the ends cleaned with a wire brush.

The moulds are then placed in position round the joint and well luted with clay and sand, and the rail-head painted with liquid clay, in order to prevent its getting burnt. The crucible containing the welding compound is placed with its taphole directly over the runner of the mould, and about 5 ft. 6 in. above it. The Thermit compound is then

MAKING A WELD.

ignited by applying a flaming vesta to the ignition powder placed in a small heap on the top of the welding compound, and after about ten seconds the crucible is tapped, allowing the liquid iron to flow into the mould, followed by the slag.

After about three minutes the clamps may be tightened and moulds removed. The slag is then knocked off with a hammer, leaving the rails perfectly welded. The whole operation lasts about thirty to forty minutes.

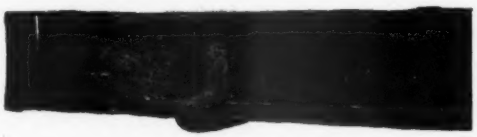
A large assortment was shown of pure metals and alloys, free from carbon, made by the Alumino-Thermic process, and now largely used in the manufacture of special qualities of steel, and in the copper, brass, and nickel industries. The metals, such as chromium, manganese, and molybdenum, are 98 to 99 per cent. purity.

A special compound for prevention of blow-holes, made up in tins ready for use, formed another feature of the exhibit. The tins are immersed into the liquid metal in the ladle immediately after pouring from the cupola. They contain a small addition of ferro-titanium, which reduces the sulphur content in the metal and creates a close-grained casting.

The company's process as used for the purpose of reducing piping in large steel ingots consists in introducing a tin of anti-piping compound into ingots with the aid of an iron rod, and is, according to the size of the block suspended, about 3 ft.

The tin is, of course, only introduced after piping has been formed, and the head layer of the ingot, which has already become solid, is broken through for the purpose. As soon as the reaction is complete the liquid steel, which is held in readiness for the purpose, is poured into the open hole.

The method of procedure is very simple and inexpensive, as only a very small amount of the compound is required. After the treatment only relatively very small flaws are found in the upper part of the block, so that the loss, which without this treatment often amounts to

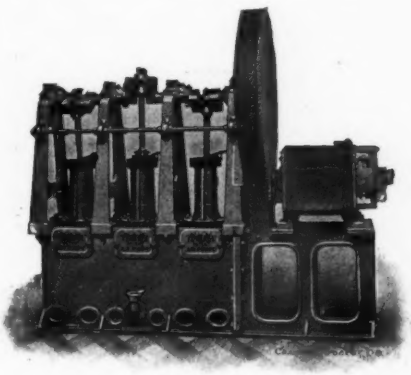


THE WELD COMPLETE.

30 to 40 per cent. of the ingot, is reduced to a few per cent. only.

THE EDWARDS AIR PUMP SYNDICATE, LTD., 3 and 5, Crown Court, Old Broad Street, E.C.—A set of three-throw motor-driven Edwards patent air pumps, with barrels 8 in. diameter by 8 in. stroke, suitable for working in connection with a surface condenser, were shown at work. The pumps are driven from three B. H.-P. motor, through chain-reduction gearing, but if preferred spur gearing can be adopted, or the motor can be direct coupled to the pump crankshaft.

In the Edwards pump foot and bucket valves are entirely dispensed with. The only valves



AN EDWARDS' AIR PUMP.

used are those which in the old type of pump are known as "the head valves."

The condensed steam, and in the case of jet pumps, the injection water also, flows continuously, by gravity, from the condenser into the base of the pump, and is there dealt with mechanically by the conical bucket working in connection with a base of similar shape and a specially designed guiding edge.

Upon the descent of the bucket the water is projected silently and without shock at a high velocity through the ports into the working barrel. The rising water is followed by the rising bucket, which, acting as a piston-valve, closes the ports, and sweeping the air and water before it, discharges them through the valves at the top of the barrel.

There being only one set of valves in the Edwards pump, the cost of maintenance and time necessary for overhauling are reduced to a minimum, while, owing to the fact that the valves can be so readily examined, the likelihood of any trouble arising through the valves giving way is practically eliminated.

We understand that the Edwards' pump has now been fitted to more than 230 of the principal electric lighting and traction stations in Great Britain and the United States, including a large number of turbine installations.

MESSRS. E. GREEN & SONS, LIMITED, MANCHESTER, exhibited a model of their latest type of economiser, containing ninety-six tubes arranged on the modern principle, that is, in two groups of forty-eight tubes each, coupled together by expansion elbows at top and bottom. The model showed the economiser applied to a 30 ft. by 8 ft. Lancashire boiler, and the method of setting in main flue; also the by-pass flue and the necessary dampers. Also to be seen were a "Wakefield" pump of the direct acting vertical type and a vertical double ram steam pump, both designed for boiler and economiser feeding purposes.

HADFIELD'S STEEL FOUNDRY, LIMITED, OF SHEFFIELD, made a very striking display of tramway track material, comprising their improved patent points of 100 ft., 200 ft., and 250 ft. radius, as supplied to the London County Council, and to other important corporations. These are so designed that the tongues are of maximum strength, consistent with smooth running, inasmuch as they are the same width on the base for their full length. The box on the side of the point not only gives efficient drainage, but is so arranged that it is suitable for the mechanism of either a movable or an automatic point, and the conversion from one to the other can be performed in a few minutes without interfering with the track or interrupting the ordinary 'car service. Among other exhibits were various types of crossings, drain boxes, temporary cross-overs and car-wheels. The latter are of the most improved type, consisting of a steel cast centre fitted with a special rolled steel tyre. A very interesting exhibit was the set of Hadfield's steel tyred car wheels which were supplied to the Sheffield Corporation Tramways, and which have given a mileage of 79,680 before being taken out of active service.

MESSRS. E. BENNIS & CO.'s exhibit showed a complete installation of overhead coal storage bunkers, as applied to a range of boilers fitted with the Bennis stokers and self-cleaning compressed air furnaces. The coal was fed into the bunker by the firm's system of elevating and conveying plant. The self-cleaning furnace above mentioned enables the supply of air to be adjusted with exactitude to the evaporative requirements of the boiler. Illustrations of the "Bennis and Miller Bennett" chain grate stoker were shown for the first time. It is claimed that this machine has many advantages over any existing chain grates, knuckle joints being used instead of the ordinary joints of present practice, doing away with all excess of cold air where it is not wanted. We are informed that excellent results have been obtained with this grate at the Kensington and Notting Hill Electricity Station.

THE automatic reversible booster which formed the conspicuous feature of the LANCASHIRE DYNAMO & MOTOR CO.'s exhibit is of the traction type, and has an output of 300 amps. for one hour, 400 amps. for five minutes, the motor being wound for 500/550 volts. The booster field magnets are laminated throughout, in order to give the quick reversal necessary when working on a traction load. A booster switchboard, made by Mr. Bertram Thomas, was also shown, fitted with specially interlocked traction circuit breakers.

A GOOD deal of attention was attracted by the fine display made by MESSRS. EDGAR ALLEN & CO., LIMITED, of Sheffield, the proprietors of the business of Messrs. Askham Bros. and Wilson, Limited, famed for points and crossings for tramway traction.

Amongst the exhibits were shown 15 ft. automatic and open points made for Leeds Corporation and fitted with manganese steel tongues and insets. These are the longest standard points used in Great Britain, and are fitted with M'Knight's silencer; 13 ft. 6 in. automatic points as made for the Hague (Holland) Tramways, and fitted with Allen patent auto-movable arrangement. When in use the points are connected together; 10 ft. 6 in. (Swansea) manganese point fitted with Marshall's patent pull push and moveable fittings; 9 ft. 6 in. double-tongue movable points connected, for use on cross-overs, or, with the addition of springs, for loops. By an arrangement in the box these points can be converted into silent points, by attaching M'Knight's silencer.

A feature of interest was a 12 ft. patent iron-bound point, the first to be made in Great Britain. It is claimed that these points never choke, are easily fitted with fish or anchor plates, and can be made of almost any length. A large assortment of crossings, joints, drain boxes, tie bars, heel plates, tramcar wheels, completed the exhibit.

ON the large stand of MESSRS. HURST, NELSON & CO., LIMITED, of MOTHERWELL, N.B., an interesting variety of the firm's specialities were to be seen, conspicuous amongst which was a double-decked four-wheel motor car, built to the designs of Messrs. Kennedy and Jenkin, for the Kilmarnock Corporation Tramways. The following are the principal dimensions and features:—length of body, 16 ft.; extreme length over fenders, 28 ft.; width of roof, 6 ft, 9 ins.; gauge, 4 ft. 8½ ins.; width over pillars, 6 ft. 6 ins.; wheel base, 6 ft. Number of inside passengers, 22; number of outside passengers, 30. This car is of the Hurst-Nelson standard type, with special design of roof giving ample ventilation. Improved stairways are fitted. There are outside dry seats,

illuminated route indicators, and Tidswell life-guards, also steps of Hurst-Nelson patent type to comply with the new regulations of the Board of Trade. The car is mounted on a standard truck of the solid forged frame type, riding on laminated and coil steel springs with steel-tyred wheels, all of Messrs. Hurst, Nelson & Co.'s manufacture.

A standard solid-forged frame, four-wheeled truck also figured prominently on the stand. This has a steel base of 5 ft. 6 in. with 31½ in. diameter steel-tyred wheel, with steel-forged axles of the builders' own manufacture. This truck was built to 3 ft. 6 in. gauge, to the order of the Perth Corporation. Other exhibits included solid forged side bar for standard four-wheel truck; pressed steel parts used in the construction of railway and tramway vehicles, made in the exhibitor's special hydraulic plant; sand box; Ratqua rail anchors; twelve-ton steel frame railway coal wagon, fitted with one end, two falling sides and two bottom doors, with patent axle boxes, all built to standard railway clearing house requirements; solid-forged frame maximum traction truck having a wheel base of 4 ft. with 31½ in. diameter driving, and 21½ in. diameter trailing steel-tyred wheels, with forged steel axles, swing bolsters riding on coil springs, and improved arrangement of brake; hydraulic pressed wrought iron wheel centres, showing the different stages of manufacture; either-side tipping wagon on self-contained turntable, and designed for carrying coal or coke; self-contained buffer with pressed steel case, specially designed for conversion of solid buffer railway wagon; roller-bearing axle box for railway wagons.

MESSRS. MELDRUM BROS., LIMITED, TIMPERLEY, had a display, showing a "Koker" mechanical stoker, combined with the firm's patent forced draught, fitted to a model Lancashire boiler front; an improved low grate furnace, suitable for Lancashire and Cornish boilers with small flues, or for dealing with the lowest grades of fuel; various models of refuse destructors, of which the firm have erected some sixty-five in combination with electricity and sewage works; also a standard furnace equipped with all the latest improvements, including the automatic secondary air supply controller, which renders it possible to ensure an automatic delivery of secondary air over the fire for smoke prevention. This supply may be automatically regulated in decreasing volume over the period required, the air supply being automatically cut off when no longer required.

THE STIRLING BOILER CO., LIMITED, OF MOTHERWELL, exhibited working models of four drum land-type and marine-type Stirling boilers; also a stationary model of the five drum land-type boiler, fitted with chain grate stoker. Photographs of several installations of Stirling boilers were on view, including those now being erected for the London County Council at their Greenwich power station.

THE HASTE PUMP CO. exhibited a series of pumps, valve boxes and a model. The feature of the Haste pump is that every endeavour has been made to allow an equal area of flow for the water, and at the same time to do away with flat surfaces to afford a straight line of flow for the liquid, in order to obtain increased pump speeds and efficiencies.

The ends of the suction and delivery pipes are fitted with glands, and through these reciprocate a tube which is expanded at its centre. In this expansion is placed a valve, which works on a guide, the combination being so designed that the water flows between two guiding surfaces, one, the expanded tube, and the other, the conical valve and tapered valve stop.

The working of the pump is similar to any other reciprocating pump, but owing to the improved design of the combined parts, the inertia of the flowing column of liquid is not destroyed, and hence does useful work.

The friction of water through one large opening as in this pump is far less than through a number of small openings, and further, a pointed valve adds much less resistance to the flow of the water than the ordinary valve girds and valves now in use.

REVIEW.

Steam Boilers, their History and Development. By H. H. P. POWLES, A.M.Inst.C.E., M.I.Mech.E. (London: Archibald Constable & Co., Ltd., 16, James Street, Haymarket). Price, 24s. net.

That knowledge which does not explain how a thing has become what it is, is incomplete and unsatisfactory. Those whose acquaintance with the steam boiler does not extend beyond existent types, will find Mr. Powles' work invaluable in tracing the details of their development from the earliest times. The first part of the volume is thus employed, a characteristic example of each type being described and illustrated, including those which, although now obsolete, have nevertheless been determining factors in the chain of development. Subsequent chapters deal with types which have become persistent.; the method of treatment adopted by the author being to give prominence to their development in relation to the use for which they have been designed, rather than to constructional detail. Water-tube boilers are very fully treated, the Yarrow experiments in circulation being fully reproduced and admirably illustrated Separate chapters are devoted to Fire-Engine Boilers, Motor-Car Boilers, Sectional and Combination Types, and a concluding chapter deals somewhat cursorily with the subject of corrosion. In addition to the illustrations in the text, which are numerous, a superb series of plates are given as an appendix, showing the various types of boilers grouped together, to assist in following out the evolution of each type.

Altogether the volume forms a valuable work of reference, and is further a splendid example of printing and engraving, reflecting the highest credit on the publishers.